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SCHOOL SCIENCE AND MATHEMATICS

MARCH 1957

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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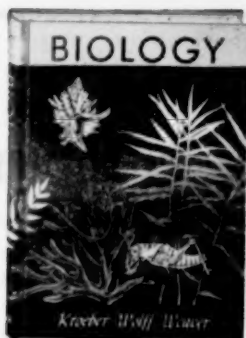
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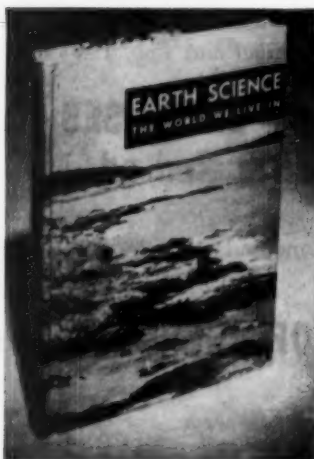
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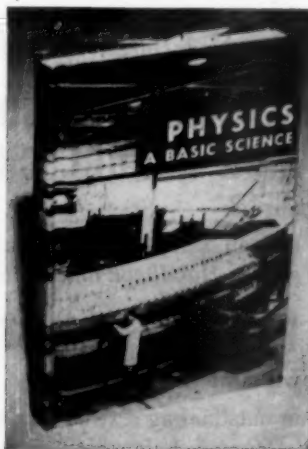
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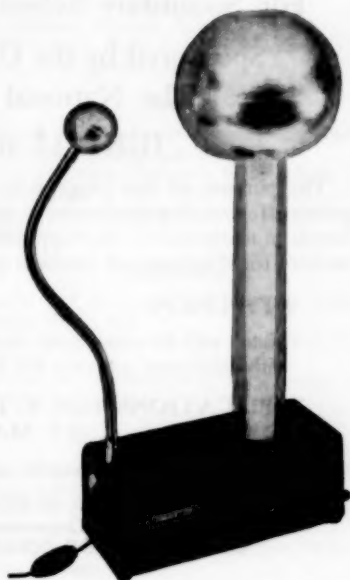
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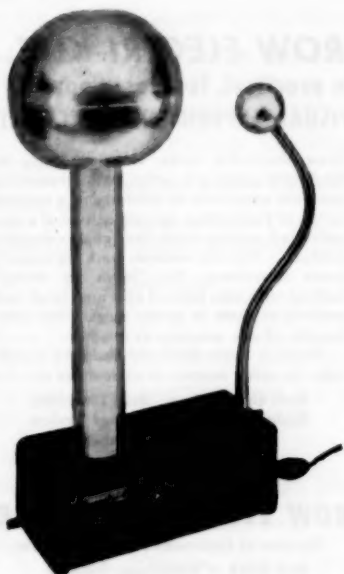
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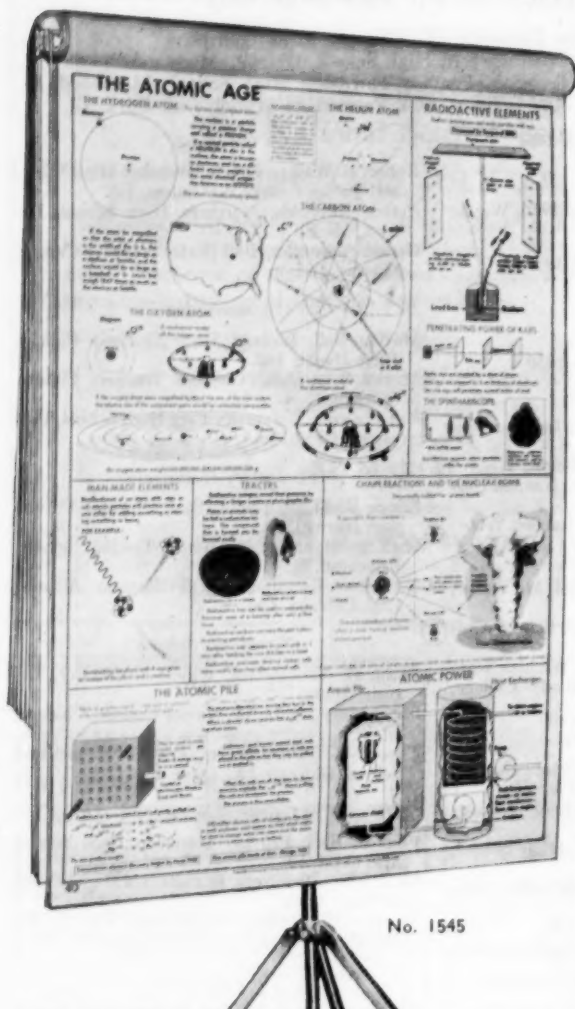
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A MESSAGE FROM THE PRESIDENT OF CASMT

EDWARD BOS

Proviso Township High School, Maywood, Ill.

I welcome this opportunity to greet all members and friends of the Central Association of Science and Mathematics Teachers, and even at this late date my greeting includes a wish for a happy, successful, and prosperous 1957.

I should like to express my appreciation to all members of the Central Association of Science and Mathematics Teachers for the trust and confidence placed in me through my election to the presidency of our organization. It shall be my earnest and constant endeavor to serve the association well. This I can do only because I have your support and cooperation in our endeavors to improve our effectiveness as teachers.

In recent years two phases of the educational program of our schools have come under careful scrutiny and criticism. In a sense there exists a strong relationship between these two. The first of these is the increased emphasis upon the importance of improved mathematics and science instruction in the schools to develop the understandings and skills basic to the solution of technological problems. The second demand upon our schools is the identification and education of the gifted student.

Referring to the first of these, it is rather unfortunate that recognition of this need for the development of understandings and skills in science and mathematics is so frequently structured upon comparisons between what Russia and the United States are doing in these subject matter areas in their schools. Such a comparison may be indicative of the degree to which our schools have failed to recognize and to release human resources, but it is hardly conceivable that high

school students will be mass motivated to become scientists and mathematicians and engineers through the knowledge of what some other nation is doing. Motivation needs to be infinitely more subtle.

Certainly there are inherent values in the understandings and skills in science and mathematics through which some students may best attain their fullest stature and thereby make their greatest contribution to society. Thus the end results are two-fold in nature and perhaps many-fold in point of continuance.

A new interest has been awakened in the education of the gifted. A danger sign to watch for is that the zeal to develop scientists and engineers may be construed as meeting the needs of the gifted. Not every student who can solve equations with facility or understands the physical and chemical nature of the world about him will make a significant contribution as a chemist or as an engineer. Society must have its poets and philosophers also, those who can rightly interpret the mundane affairs of the times.

The pressures which society is placing upon the schools to face these two aspects of education are peculiarly significant to all teachers of science and mathematics. An important key toward solving our problems lies in our ability to identify true values and to provide effective instruction for those students whom it is our privilege to teach.

Personally, I should welcome seeing in the association journal SCHOOL SCIENCE AND MATHEMATICS this year many articles which face the problems mentioned above. Who better than we are qualified to develop philosophies, policies, and standards of instruction in science and mathematics. Each contribution may be an important facet of a fully developed program. This is the time to make our strengths felt.

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LANGUAGE ASPECTS OF ARITHMETIC

WILLIAM E. YOUNG

The University of the State of New York, Albany 1, N. Y.

The quantitative plays a large role in our living. Of the most common words in our language one word in ten is a mathematical term. The proportion becomes one word in every four if we include indefinite quantitative words. Although the child, therefore, constantly encounters many quantitative terms in and out of school, we must not conclude that this constant experiencing means that the mathematical concepts for which these quantitative terms stand are acquired.

That such is frequently not the case may be due to the superficial nature of the child's experiencing. Mary in the fifth grade reads in her textbook, "The United States imports about one billion pounds of coffee from Brazil each year." The teacher subsequently asks, "How many pounds of coffee does the United States import from Brazil each year?" Mary replies, "The United States imports about one billion pounds of coffee from Brazil each year."

The child may experience inaccurate use of the terms. Johnny—a seventh grader—goes with his dad to see the Braves play the Dodgers. Johnny hears his dad ask a neighbor in the stands, "What is Aaron's batting average now?" The fan replies, "I believe today's paper gave his percentage as 342." If Johnny asks his dad, "Say, Pop, what does 342 mean?" his dad may give back, "Why, 342 means 342. That's his percentage. It means he's leading the League, for one thing."

Nellie hears her mother say, "A dollar is worth only 58¢." . . . Nellie wonders, "Does that mean that 58¢ is worth a dollar?"

When some persons listened this fall to the campaign addresses of presumably the greatest men and the foremost leaders of the country, they may have got the idea that it is possible at one and the same time to spend more money on defense, to appropriate billions for foreign aid, to raise pensions and salaries, to build superhighways across and up and down the continent, to give the farmer 90% parity, to provide for federal financing of school construction, to cut the federal debt in half, and to reduce taxes.

All such use of quantitative terms may make for as much confusion as understanding.

Some quantitative terms are quite at variance in literary or popular use from their mathematical meaning: *borrow*, *carry*, *divide*, *multiply*, *proper* and *improper*, *radical*, *similar*.

Some quantitative terms have different mathematical meanings, and they are variously used in the same arithmetic textbook: *base*, *dividend*, *even*, *figure*, *remainder*, *round*.

Finally, we should note the technical terms that the child does NOT encounter very often—except in school and then only in the arithmetic period; such as: *addend*, *hypotenuse*, *minuend*, *quotient*, *subtrahend*.

In order that the child shall understand arithmetic, he needs to experience more than the words. He must have dynamically interpreted the processes and operations which the words signify.

Horn¹ has pointed out, "On the basis of the hypothesis that words occurring in the first twenty-five hundred of the Thorndike list should be intelligible to fourth-grade children, the following sentence should be easy to understand: *The square of the sum of two numbers is equal to the square of the first added to twice the product of the first and second added to the square of the second*. All of these words are among the two thousand of highest frequency in the Thorndike list. On the other hand, the following sentences should be quite unintelligible: *Daddy helped me with my arithmetic until bedtime. I got a bracelet, a toy dresser, and some gum for Christmas. Brother got a baseball and a sled.*"

The number of times which a child has encountered a word or phrase *may help* to determine whether he obtains the appropriate concept for that word or phrase when he meets it in his arithmetic work. But more important is the quality of the previous experiencing. Has the child had concrete experiencing which has served overtly to demonstrate the meaning of the word or phrase? If not, does the child know how to construct an experience that will interpret the conditions of the context?

Buswell² has described the results of asking 40 children in the third grade to estimate *reasonable answers* to problems. Sixteen pupils had no idea what a *reasonable answer* is. Several other pupils had erroneous ideas. Two children had the concept that a *reasonable answer* is a *cheap answer*. In order to obtain the meaning of a *reasonable answer*, these two children were referring perhaps to their previous experiencing in the market with mother. When the price of butter was *reasonable*; that is, when the price was *cheap* enough, mother could buy it. Many times, however, mother bought oleo because it was more *reasonably* priced; that is, it was *cheaply* priced. These children were meeting a new situation by referring to the most meaningful experiences which they had had with the concept of *reasonable*.

We can not always be sure that the child who verbalizes fluently understands clearly. Susan readily recites the definition of an isosceles triangle and that of an equilateral triangle. But Susan doesn't under-

¹ Horn, Ernest. *Methods of Instruction in the Social Studies*, pp. 167-168. New York, Scribner, 1937, O.P. 1955.

² Buswell, G. T. and John, Lenore. "The Vocabulary of Arithmetic." *Supplementary Educational Monographs*, No. 38. Chicago. University of Chicago Press, 1931.

stand that an equilateral triangle is isosceles also. She knows what a rectangle is and what a square is. She doesn't perceive that a square is always a rectangle.

Neither can we be sure that the child who can not verbalize an acceptable academic explanation does not understand the concept. Fred may be asked, "What happens when zero is added to a number?" Fred replies, "Nothin' happens." But the teacher wants the textbook rule: *When you add zero to a number, the answer is the number.* How would you and I verbally define 5? We know what 5 is. We can represent it in more than a dozen ways. We can show 5 as 5 apples, 5 roses 5 pennies, 5 marbles, 5 sticks, etc. We can demonstrate overtly the concept of *fiveness*, but we are hard put to it if we try to give a verbal definition of 5.

We want the child to understand *before* he verbalizes. If he verbalizes first, he may stop right there. Furthermore, as Van Engen³ points out, "Developing the awareness of a generalization prior to verbalization facilitates learning."

In summary, here are a few practical suggestions:

(1) Try to develop overtly and inductively the meaning of the basic symbols of arithmetic: the numbers and the symbols of operation.

(2) Reduce the number of technical words to a minimum. Such a word as *addend* could be omitted entirely. On the other hand, fairness forces us to observe that children do not object to technical terms provided they are tied in with interesting and meaningful experiences. Examples are: *it* in the game of tag; *free* in hide and seek; *out*, *run*, and *Texas Leaguer* in baseball; and *halfback* in football.

(3) When a technical term must be used in the first six grades, develop its mathematical meaning by relating it within the experience of the child. Have the concept grow out of a familiar and customary activity in which children are involved.

(4) Once a term is used, provide for its repeated and continued use. I picked up a fourth grade textbook the other day which introduced fairly well the concept of *average*. It told of how Dick sold newspapers each day. On Monday he made 36¢; Tuesday, 28¢; Wednesday, 48¢; Thursday, 40¢; and Friday, 28¢. But Dick wanted to know how much he earned a day. Well, in five days he had earned \$1.80. If he had earned 36¢ each day, he would also have earned \$1.80 in the five days. We say that Dick earned 36¢ a day *on the average*.

Such an explanation is fairly good provided there are other experiences of an equally meaningful character and provided the teacher sees that some of these experiences directly involve the children in

³ Van Engen, Henry. "The Formation of Concepts," Chapter 3, p. 94, in *The Learning of Mathematics*, the Twenty-first Yearbook of The National Council of Teachers of Mathematics. Washington, D. C. The Council. 1953.

the class. But this particular textbook has nothing more about averages. The subject of averages is wrapped up in three consecutive pages, and it just never occurs again throughout the whole book.

(5) Above all, keep in mind that what a child needs in order to learn, to acquire correct concepts, are sensory-motor experiences. He needs to see, to hear, touch, taste, plan, make, do, and try out. A child is interested in experiences which involve him directly and which concern or seemingly concern his own welfare. These are the experiences which hold the child's attention and which make meaningful and accurate the ideas which he acquires and uses.

SECTIONAL MEETING OF THE
ILLINOIS COUNCIL OF TEACHERS OF MATHEMATICS
SPRING 1957

- | | |
|--|---|
| <p>1. <i>March 23: Granite City</i>
 Chairman: Gussie Fisher Phillips
 (Mrs. G. Phillips)
 2259A Edison Ave.
 Granite City, Illinois
 Theme: Mathematics for the gifted
 Speakers: Jesse Osborn; Lawrence
 A. Ringenberg; others to be an-
 nounced</p> | <p>5. <i>April 10: Charleston</i>
 Chairman: Lester R. Van Deventer
 Department of Mathe-
 matics
 E.I.S.C.
 Charleston, Illinois
 Afternoon and evening meeting
 Speakers: Frank B. Allen; Robert
 E. Pingry</p> |
| <p>2. <i>March 30: Joliet</i>
 Chairman: Mary Louise Fisher
 354 Whitney Avenue
 Joliet, Illinois
 Speakers: Henry Van Engen, Ele-
 mentary Section; William Golom-
 ski</p> | <p>6. <i>April 13: Kewanee</i>
 Chairman: Harriet McCarthy
 700 South Chestnut St.
 Kewanee, Illinois
 Speakers: High School Section,
 Max Beberman, Project Direc-
 tor, and Project Staff of the
 University of Illinois Committee
 on School Mathematics. Other
 speaker to be announced</p> |
| <p>3. <i>March 30: Carbondale</i>
 Chairman: Dilla Hall
 820 South Illinois Ave.
 Carbondale, Illinois</p> | |
| <p>4. <i>April 6: Normal</i>
 Chairman: Douglas R. Bey
 Department of Mathe-
 matics
 I.S.N.U.
 Normal, Illinois
 General Theme: The Changing
 Mathematics Curriculum
 Speakers: Bruce E. Meserve; Henry
 Van Engen
 Four group discussions on the basic
 theme of the conference for:
 primary grades
 intermediate grades
 upper grades
 high school</p> | |

For additional information, write to sectional program chairmen.

THE HIGH SCHOOL SCIENCE TEACHER

SISTER HELENE VEN HORST

Marycrest College, Davenport, Iowa

"Unless something is done to improve the quality of science teaching in this country, 'we may be destroyed by intellectual torpor, not weapons'." Such is the message of former American Chemical Society president Joel H. Hildebrand in his recent address to the National Academy of Science (1). Possibly no other topic is of such immediate concern as the present and anticipated future shortage of scientific personnel in our country. As of June, 1955, the shortage (2) of scientists and engineers in industry, government, and teaching reached a high of 30,000. More specifically, the number of qualified science and mathematics teachers in the United States dropped 53 per cent in the last five years (3), although the high school enrollment has increased by 16 per cent. The National Education Association (4) estimates the need for new science teachers at the rate of 7,700 a year, yet the supply approximates only a third of this number. The widespread ferment existing among our scientific, government, and educational personnel is probably the most hopeful sign for the future. Large and small groups alike are investigating the problem. Let us hope that the solution will not be found when it is too late!

It is recognized that our high school science teachers hold the key to the vast reservoirs of raw materials from which our future scientists and engineers are fashioned. It would seem, then, that the adequate training of secondary teachers and the selection of candidates for this profession are two important phases in the solution of this problem. The most appropriate way in which to accomplish these objectives is not the purpose of this paper. It is intended rather as a means of bringing into focus for the encouragement and stimulation of others the nationwide efforts which are being made to improve the status of our science teachers and to suggest some existing areas for study.

With the rapid increase in enrollment of our secondary schools the problem of adequate teacher preparation varies significantly from that of several decades ago. Hildebrand (1) points out the need at the college level for "tremendous improvement in the quality of science teaching." The over-emphasis of today's child-centered curricula, he says, has replaced training of the intellect with training for social adjustment and the art of gracious living. Hence, it seems plausible that the problem of training the teachers should be dealt with from two aspects—the pre-service training of our future teachers and the in-service training of the experienced teacher. In consideration of the pre-service training of secondary teachers, the question might well be

asked: Are the undergraduate schools—the teacher training school, the liberal arts college, and the university—giving the student the best and at the same time the most adequate training to prepare him for his service as a science teacher? Is the science-teacher curriculum a result of thorough planning with a view to what will best qualify the student as a teacher of science, or is it a question of merely meeting state requirements? Our research laboratories are of necessity equipped with the finest grade of equipment and staffed with leading scientific personnel. Yet in the training of our future scientists little care is exercised in many cases in the preparation and selection of our teaching personnel. A recent survey (3) shows that between 250,000 and 400,000 U. S. high school students are taking their mathematics and scientific training from teachers who are not qualified to teach these subjects.

According to statistics on certification requirements (5) the number of semester hours of professional education required by the states varies from 9 in Mississippi to 27 in Washington. Requirements in subject matter fields also vary considerably from state to state, some being very rigid and others more flexible. A study of these requirements would indicate that in many cases the certification program on the B.A. level is relatively thin in subject matter areas. Would that our scientists were as exacting in subject matter preparation as our state departments are in their requirements in professional education!

On the other hand, is it possible to earn in four years of undergraduate college sufficient credit hours to qualify one for state certification as well as to prepare one adequately in all science fields or appropriate combinations of them? Some colleges are considering the five-year program. In such programs perhaps more discussion of the topic of distribution of professional and subject matter courses would be beneficial. It would seem that if our scientists would work cooperatively with those in professional education that both could profit from a better understanding of each others views. Much less criticism and a better program would result if the two groups would discuss their points of view openly.

The problem of adequate preparation in many branches of science remains a burden to all concerned. Statistics published recently (6) give evidence of the need for training in at least several areas of science. For example, results of a survey of 29 states, the District of

	<i>Majors</i>	<i>Minors</i>
Physics	126	75
Chemistry	178	145
Biology	303	247
General Science	805	642

Columbia, Hawaii, and Puerto Rico, indicate that the demand for teachers in September, 1955 was as shown in the table.

The 178 majors in chemistry, as a typical example, were required to teach in the following minor areas: biology, 55; physics, 22; mathematics, 21; general science, 19; social studies, 9; physical education for men, 6; and one or two in each of the following fields: agriculture, art, commerce, foreign language, home economics, journalism, music, physical education for women, and others.

In a recent study of the problem of science teachers, Hurd (7) points out that many of our high school teachers are teachers first and chemists second, third, or fourth. It might seem that many of our colleges and universities are geared primarily toward preparing their students for industrial research, graduate school, or teaching in a more or less specialized area. They should not be criticized if these are their objectives. Something more should be done, however, especially on the part of the graduate schools if they are to share the burden of improving science teaching in our secondary schools. Too often the zealous high school science teacher, desiring to earn graduate credit during the summer months, is put in a class with students whose level of interest and achievement is considerably more specialized than that of the average high school teacher. Rather than continue in highly competitive areas, the high school science teacher will work for his advanced degree in the field of education, which, in the opinion of many, "is the easiest and quickest way to a graduate degree."

The extent to which colleges are contributing by way of course offerings geared toward improving the present science teacher emergency was investigated by the STIP division of AAAS (8). Results showed that only 11 per cent (82 of 727) replied affirmatively to all phases of the problem, namely, (1) offering special subject matter courses for graduate credit and for teachers only; (2) offering correspondence courses for teachers of science and mathematics; and (3) offering extension courses for teachers off campus. Some colleges indicated participation in one of the three areas, and many indicated other types of services such as assistance in classroom activities and career guidance, workshops, summer institutes, representatives to in-service conferences, lecture series, and scholarships.

The apparent lack of interest on the part of the high school teachers in response to special course offerings made by the graduate school is not always blameworthy. Frequently the inadequate salaries offered to our high school teachers make it necessary for many of them to seek summer employment. In a survey of teacher salaries (9) for the 1953-54 academic year one state with the lowest salary reported an

annual average of \$1,864; the highest salary, an annual average of \$4,787. It was further shown that the average annual salary of instructional staff members is consistently lower than the average annual personal income per member of the labor force. Salaries paid to secondary school appointees (10) during 1954-55 rose to \$4,472 for men and \$3,851 for women.

Perhaps there is no immediate solution to the problem of improving the status of the in-service teacher, but many attempts are made in the direction of upgrading his intellectual achievement. Special recognition should be given to the work of AAAS through its STIP committee and to the National Association of Science National Research Council in its Arlington pilot study (11). The study involving the use of science and mathematics counselors (12) is likewise praiseworthy.

The science institutes and summer schools being sponsored cooperatively by industries and graduate schools are certainly lending support to the problem. However, should these grants serve as many as 2000 teachers, this would represent only a small percentage of science personnel in the nation's 25,000 high schools.

While the problem of giving adequate attention to the pre-service and in-service training of the high school science teacher is of utmost importance, nevertheless the shortage of qualified teaching personnel must not be viewed as a temporary crisis unless concerted effort is made on the part of industrial and professional scientists to stimulate interest in the teaching profession. According to Rickover (13), 60 per cent of the best students graduating from high school do not go to college. This amounts to approximately 250,000 a year. It would seem that there is a valuable field which might be exploited for prospective teachers. Two areas of study are evident: (1) How can more students be encouraged to take science and mathematics in high school; and (2) How can the science teachers be encouraged to continue in the teaching profession for which they have been prepared.

The outstanding work accomplished by local, state, and national science fairs is doing much toward promoting interest in science. The cooperation given by local sections of the American Chemical Society is a stimulus to both teachers and students. During the past year (14, 15) as many as 40 of the 149 sections supported fairs along with schools and professional and business groups. Participation by these groups consisted of helping to raise funds to finance the local fairs, supplying judges, setting up career booths, distributing pamphlets on science careers, and assisting with long range planning. The local fairs give opportunities for all students to exhibit their projects. Entries in state and national science fairs will then result from winners in local sections.

Perhaps much more could be done in this area. If additional resource persons could be made available to assist and counsel the high school students in their specific projects even greater interest could be stimulated. Frequently where classes are large and the science teachers have crowded schedules and heavy student loads there is little time or energy left to assist the better students. In other instances the teachers themselves have not had sufficient experience with the direction and construction of projects to enable them to be of much help to these students. In such cases it would seem that resource persons from industry, colleges, and universities would be of much assistance to both student and teacher.

Probably the most important factor in stimulating student interest in science courses is the teacher. A well-qualified, enthusiastic teacher is the best promotor of scientific interest. Contrariwise, a student poorly taught will be bored with the course and can scarcely be expected or encouraged to become a teacher of that subject. Anything, then, that would be a positive step in creating such enthusiasm in science and mathematics should be promoted.

The most immediate source of science teachers and at the same time the most serious problem is the drop-outs in those prepared to teach in our secondary schools. According to statistics (16) the loss in teachers is serious. Only 57.8 per cent of the men who qualified as high school teachers in 1955 entered the profession; 68.5 per cent of the women thus qualified followed this career. Further, the area of chemistry attracted only 46.6 per cent of those prepared to teach chemistry; biology attracted 55 per cent, and physics, 56.9 per cent. From this same report it is noted that the drop in the number of those prepared to teach in high school is, with the exception of agriculture, the greatest in science, namely, 51.3 per cent. By way of comparison, the drop in home economics teachers is as low as 7.3 per cent.

Could more be done to advantage in encouraging young women to pursue the field of high school science teaching? It is recognized that many talented young men will be interested in doing graduate work so as to prepare themselves for industrial research or graduate teaching. On the other hand, talented young women may not always be disposed to invest the time and money required for extended and strenuous graduate training. It would seem that with proper motivation and a well-designed program that these students might be encouraged to pursue the teaching profession. The age-old criticism that because of their short tenure women are not a good investment no longer has much validity. Statistics show (17) that while the exact number of married women covered by the survey is not known, it is reported that only 5.7 per cent of the 65,000 chose to devote full time to homemaking.

Obviously one of the most potent ways of stimulating interest in the teaching profession is to boost the salaries of the high school teachers. This will have its good effects on the teacher and student alike. If the student sees that such a profession is not only interesting but likewise a good investment for his education, he will be encouraged to pursue such training regardless of its attendant difficulties. Here are some facts (13). At present the United States is spending about 2.5 per cent of the national income on education whereas we spend more than 4 per cent on recreation. More money is spent for comic books than for all textbooks used in our elementary and high schools. The amount spent for advertising in the United States in 1951 was \$199 per family whereas the amount spent for primary and secondary education was \$152 per household. Within the next ten years 25 billion dollars will be spent on school buildings. What amount is being spent and what preparation is being made to assure our nation of more and better-trained teachers? Is it not equally important to invest in well-trained teachers as in elaborate and ornate buildings? It takes just two years to build a building but a minimum of four to six years to prepare a teacher.

In the opinion of scientists, and contrary to that of some educators, the solution to the problem of stimulating greater interest in high school science does not seem to be in the abolishing of science teaching in the elementary grades. Rather, the goal should be to supply all our schools with well-qualified science teachers whose first and foremost interest lies in the promotion of science.

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Know more than others if you can, but do not tell them so.

—LORD CHESTERFIELD

THE PROGRESS OF IRON ORE

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The beginning of the iron ore deposits in the Lake Superior region goes back as far as 700,000,000 years ago, when an ancient sea covered the land. This Iron Sea extended from the Arctic down through Ontario, covered most of Minnesota, Wisconsin and Michigan and far beyond them. In the sea there were large and small islands and along their shores the rocks were very different, due to previous faulting and folding of the earth. The waves of this sea beat upon magnesian limestone and slate and quartzite, or upon lavas from an older ocean.

This Iron Sea contained little life, except for simple organisms, and the shores were mostly huge rocks. Out from the beaches mud was being deposited and it sometimes mixed with volcanic fragments. In the deepest water, iron, silica and other minerals from the bottom were being pushed up to form the iron formations hundreds of feet thick.

Most of the iron formation was composed of iron silicate or thin layers of silica and iron carbonate, often found interbedded. This was not really ore, even though it contained 20 to 35% iron, but parts of the formation later became ore.

This iron formation was so heavy that it pressed on the sea bottom. The erosion on land was making these areas lighter, so that the underlying rocks began to fold and crack. Lava was forced up through the cracks and hardened between layers of the iron formation. This volcanic action pushed the iron formation above the surface of the sea where it was partly worn away. Farther from the shore some parts of the sea became so shallow that mud was laid down instead of iron bearing materials. Still farther from shore the volcanic dust sank to the bottom and mixed with iron deposits.

With great movements of the earth's crust and volcanic flows, the land and sea levels became changed and the forming of the iron formations stopped. In some parts of the Lake Superior region the sea became so shallow that the iron formation was buried under mud and sand. In other parts the iron formation pushed up and became land and some of it was worn away.

Some of the original iron formation in the Lake Superior region became oxidized and folded and faulted several times. After it was oxidized it contained 25 to 40% iron. This, too, was not really ore but continued to change. Some ore was formed by the churning action of the waves which washed away the lighter particles. Most of the ore

was formed when underground water washed out some of the silica in the faults that were U or V shaped troughs.

In place of the silica, iron oxide was deposited so that, in some areas, the improved ore contained 65 to 70% iron. Most of the formation never became ore, although much of it contained some iron. The pressure and heat with the folding changed the soft brown limonite or rust spots to hard black shiny hematite and sometimes to a heavy black magnetite.

Lake Superior lies in a great basin in the rocks which must have been filled with sediment several hundred million years ago when the ice age or glacial period began. There were several ice invasions and each time the Superior basin was scraped and the softer rocks pushed south. After repeated scouring by the ice, which finally retreated, Lake Superior had been formed, and a layer of earth and rock laid over the ore bodies, called overburden.

The iron oxide, or rich iron ore, is called high grade iron ore. It is also called the direct-shipping ore, because it can be shipped directly from the mines to the steel producers. When the water has not completely improved the minerals and the proportion of iron is smaller than that of the sand and impurities higher, the product is called low grade iron ore. The original formation is the taconite. Low grade iron ore and taconite must be processed extensively before they can be shipped.

The Sioux Indians knew about "red earth" in the Lake Superior region and French missionaries who traveled into that wild country wrote about seeing iron ore there as early as 1660. This was almost forgotten for nearly two centuries. In 1844, a group of government surveyors near Negaunee in northern Michigan noticed that their compass needle was acting in a very strange manner. They were certain that its unusual movements must be due to the presence of a large body of iron. On searching, they found a bed of rich red iron ore. So, by accident, these men re-discovered what was to become part of the world's largest commercial iron mining region in northern Michigan, Minnesota and Wisconsin.

Ore was reported in Minnesota as early as 1850 but it wasn't until 1875 that any systematic search for ore was taken. In that year the Vermilion range was discovered in Minnesota and its development began. Iron ore was reported on the Mesabi range by several geologists and explorers. Early exploration was done on the eastern portion of this range and no large deposits of good ore were found. That area contains principally the low grade ores. In spite of disappointments, the search to find commercial iron deposits continued. Among the more persistent of the Mesabi explorers were the Merritt brothers, sometimes called the "Seven Iron Men." It was one of their tests pit

crews which made the first discovery of high grade ore in the area of the present Mountain Iron mine in 1890. This was followed in 1891 by the discovery of ore in the area to the west. These discoveries started a wild rush of exploration which resulted in further discoveries near the towns of Hibbing, Virginia and Eveleth, Minnesota. The Cuyuna range, the last of the Minnesota ranges to be discovered, was different from the Vermilion and Mesabi ranges because no iron bearing rocks were exposed at the surface. Probable iron bearing material was detected there in 1895 by using a magnetic dip needle. This type of survey, along with drilling, traced out the limits of the range.

In 1893 the Merritts, who had obtained large amounts of land and had invested a great deal of money in attempts to mine and ship their ore, were forced to give up their holdings to John D. Rockefeller. Rockefeller agents proceeded to buy additional Mesabi ore lands and mines, or took leases on them. Carnegie's company, the American Steel Barge Company, shipped most of the ore. Henry W. Oliver became interested in ore and mining possibilities and formed the Oliver Mining Company. In 1901, Hill, another financier of mining properties competing with Rockefeller, was persuaded to combine forces with Rockefeller and found one company. This became the United States Steel Corporation. Today there are three large mining companies shipping Mesabi ore; the Oliver Iron Mining Division of United States Steel, the Reserve Mining Company and the Erie Mining Company.

Production from other iron ore producing districts seem small compared to the Mesabi but they are important because of the kind of ore they produce and their locations. The Lake Superior district includes five producing ranges beside the Mesabi. In 1942, the peak year, the production from the Mesabi was 70.3, Vermilion 1.9, Cuyuna 3.0, Gogebic 6.2, Marquette 6.5, Menominee 4.9, to total 92.8.

The Vermilion range ore is hard, dense hematite that is mined by underground methods. It has shipped from one to two million tons of high grade ore annually during the past sixty years. The Cuyuna range ore is softer and much of it requires beneficiation or improvement. A large part of Cuyuna range ore contains manganese. This range has both open pit and underground mines but most of the ore comes from the open pits.

The Marquette, Gogebic and Menominee ranges in Michigan and Wisconsin produce underground, direct shipping ore of a hard, lumpy type. Some of the mines are very deep for iron mines, the Eureka being 3600 feet below the surface. Production from the Marquette and Gogebic ranges are about equal, with the Menominee a little less.

The Gogebic lies partly in Michigan and partly in Wisconsin, with production greater on the Michigan side. Among the states, Michigan is the second largest ore producer, with Minnesota the first.

Alabama is the largest iron ore producing state outside the Lake Superior district. Its red ores have a low iron content and brown ore concentrates plus high grade ore from the Lake Superior region and foreign sources are used for blending purposes to enrich the ore for the blast furnace. Arkansas has a small amount of magnetite. California ships mixed hematite and magnetite. Georgia produces brown ore concentrates. Missouri mines by the underground method and concentrates the crude ore. Nevada has small shipments of iron ore. New Jersey and New York ship magnetite lump ore and concentrates. New Mexico produces some magnetite. Pennsylvania has increased production of concentrates, sinter and pellets, and new magnetic discoveries have made necessary the building of beneficiating plants. Tennessee and Texas have small areas of brown ore. Utah has been producing some iron ore which is mined by open pit methods and some of it is beneficiated. Virginia produces iron oxides for use as a pigment in making paint. Wyoming produces ore that is direct shipping grade which needs partial treatment after shipment.

All ores are not the same. The most common iron ore is soft to medium-hard, yellowish brown to reddish or bluish-brown in color. It contains ferruginous chert, which is an iron bearing, fine crystallized silica. The term ferruginous means iron oxide, hematite, limonite or goethite. Chert is a general term for a fine crystallized silica. Hematite is an iron oxide. Limonite is an iron hydroxide. Goethite is an iron hydroxide similar to limonite. When the wall rock of a mine is a slate-type material, the iron ore in the mine is usually soft, dark red or bluish-red, and argillaceous or claylike. If the wall rock is a cherty type the ore in that mine is medium hard, somewhat sandy and generally breaks into small blocks.

The high quality ore is medium soft, reddish-blue hematite. Iron content has run as high as 68% with a low phosphorus content. This ore is exceptional and limited in quantity. Wash ore, or low grade ore, is disintegrated ferruginous chert and is in the form of fine sand which will wash out, leaving the iron oxide as the concentrate. Another low grade type is a brownish yellow limonite which is low in silica and more claylike.

Each of the ores will have wide variations in chemical analysis within its own group. Suppose manganiferous iron ore is needed. During the mining of this type of ore, the shovel is very apt to produce high manganese with low silica and medium phosphorus while another twenty feet along the same cut it is apt to run into iron. Moving along the same cut may produce a good grade of iron with

low silica and little manganese and proceed from there to iron ore that will run low in iron, low in manganese and with a silica that will be under 15%, with a 19 to 20% moisture, a low-combine ore.

If an analysis of about twenty-five cars of ore ran 18% manganese with a .32 phosphorus, the experts would know that it had a fairly good iron content and was low in silica. Yet the next time they needed high manganese with low silica they would dig from that area but would get ore with 6% manganese, .75 phosphorus and 14% silica. Sometimes when opening a new ore body the first cuts reveal a high moisture content, running 22 and 24% in moisture. The high moisture content makes this a low grade ore and it would be stockpiled and not touched for about six weeks. Then, when it was possible to use some of this low grade material, a shovel would move into the stockpile and load about fifty cars. They might suddenly find on analysis that now the stockpiled ore ran about 10 to 12% moisture. Through aeration, this pile had become a high grade because of the loss of from 10 to 12% in moisture. If they tried to stockpile more of the high moisture crude ore with 20% moisture, after six weeks this ore might have exactly the same moisture content as when it was stockpiled. The first ore piled gave up about half of its moisture. The second pile retained its moisture over the same period of aeration.

Iron ore never occurs in a pure state. Impurities in varying quantities are always found. Ores contain elements which affect their color, their structure, and their chemical action in the furnaces of the steel mills. Ores may be brick red, or varying shades of red, yellow, and purple deepening to black. They may be powdery and loam-like, or they may be hard rock. The proportions of iron, silica, alumina, phosphorus, sulphur and moisture determine whether iron ore is good or poor. When the ore contains more than 50% iron, it is a high grade or direct shipping iron ore.

The grade iron ore is important in Minnesota because of the process of mining by the open pit method. This process, also called strip mining, is similar to excavating for a basement. First the strata of the earth are determined from drill hole studies. This tells the mining man the depth and angle of glacial drift or overburden, the walls of slate and other less valuable material and finally the ore bodies themselves. Bench construction follows. This is an actual terracing step which does two important things. First, it shears a vertical surface to a specified depth for controlled blasting. Second, it provides a base for both tracks and roadways necessary for removal of ore and clean up of waste. As mining increases, so do the benches and more deep does the open pit become. This eventually leads to expansion of the surface area of the ground hole. It allows for removal of ore without the risk of slides or crumbling. Electric shovels dig out the ore ma-

terial into diesel powered engines. Hopper cars and tilt-beds do the loading and unloading. Sturdy trucks or trains climb the graded benches from the source of the ore to the washing plants. Working with the trucks and the trains in some mines are mechanically-driven conveyor belts which endlessly carry the burden up to the mouth of the mine. The area in which direct shipping open pit iron ores are found is very small. It covers less than five thousand acres of north-eastern Minnesota.

The Mesabi ore is also classified by mining methods. In most areas, the overlying glacial drift is so thin that open pit or strip mining methods can be used but in some places the surface is so deep that the ore is mined by underground operation. In this method, shafts 200 to 3,000 feet deep are sunk into the earth. At various levels, where the ore layers occur, passageways are dug into the ore. Sometimes the tunnels extend as much as a mile from the shafts. The ore is blasted loose, loaded into cars which are hauled by electric locomotives to the main shaft, and from there are hoisted to the surface in small cars called "skips." Other cars receive it and carry it to the stock piles. These mines operate all year. The cost of production is an important factor in which method is used. Because of this, most of the ore is produced by open pit mining, even when the surface to be stripped off is 200 feet deep. Underground mining is expensive on the Mesabi because ore beds are wide and rather shallow. With new methods of open pit mining, a few underground mines have become open pit mines today.

Mining engineers have made great advances in the development of low grade ores, which have an iron content of between 35 to 45%. These ores must be beneficiated or improved. Beneficiation is any operation performed on ore after it is mined to increase its value and usefulness. This includes operations involving fine grinding, followed by mechanical, electrical or chemical sorting and drying or agglomeration or concentration by heat. These more complex and expensive operations produce a concentrate in which the iron has been separated from waste materials. The beneficiation treatment depends on the characteristics of the ore and what is needed for shipment.

Because of the rise in cost of production, the specifications must be very exact. The ore should not be in large lumps because they heat up and reduce too slowly in the blast furnaces and it must not be too fine or it will blow away as dust. The ore desired must contain no lumps much larger than two to four inches, with little or no material finer than one-eighth inch. The particles should be one-fourth to three-fourths inch in diameter. Most of the direct shipping ore from the Mesabi range contains everything from three to four inch lumps down to the finest dust. Years ago it contained lumps as large as

twelve inches or more but now most of this material is crushed before shipment and sometimes the fine dust is screened or washed out before the ore enters the blast furnace.

Ores of various grades and types are mixed near the loading docks and furnace plants to produce grades that are ordered by the mills. This mixing is very important and the ores are carefully analyzed. To produce a grade desired by a customer may involve mixing ores from several properties and the production of a certain grade or type of concentrate. Beneficiation plants are constructed to produce desired low grade products that would be unacceptable if they were shipped without mixing.

Low grade ore is found extensively in the Lake Superior district, and is easily mined, but it contains too much silica for direct shipment. However, the silica is in the form of fine, free sand and the good ore particles in the form of fairly coarse lumps. Concentration of this material is a fairly simple operation as all that is needed is to wash away the sand, leaving lumps of very good iron ore. In comparing the crude low grade wash ore and the wash ore concentrates, it can be seen that the concentrates are coarser than the crude ore. Crude wash ore contains 42% iron and the concentrates contain 58% iron, while the tailings, or waste material, contains 25% iron. In ore of this type, about as much crude ore goes with the waste as is shipped as a concentrate. This means that it is necessary to drill, blast, mine and wash about twice as much ore as is necessary with direct shipping ore.

Low grade crude ore that needs more than washing to produce a good concentrate is called a "retreat" type of ore. This means that the washed ore must be "retreated" in order to produce a usable ore. This type of ore contains both fine and coarse silica. The fine silica can be removed by washing but the coarse silica is about the same size as the iron ore particles and, therefore, needs further concentration.

The present production of concentrates from low grade ores has not had the publicity that taconite beneficiation has had yet they account for about a third of the Lake Superior district's annual production of iron ore. There are two general types of low grade iron ore concentration methods used but several other methods have been tried. The washing operation and heavy media separation are preferred methods.

The washing operation is usually preceded by a crushing step which reduces the size of the ore particles to three to four inches or finer. This crushed material is then washed on screens, the oversize being finished concentrate and the undersize going to some other type of washing equipment which separates the coarse ore from the sand. The sand product, which contains some good, fine ore, then goes to

classifiers of various types in which the final separation is made. Percentage weight of the total ore recovered as final concentrate varies greatly at different plants but is usually between 50 and 70%. The grade of concentrate also varies greatly but the average has 12% silica. While silica is a little high in most washed concentrate, the structure is excellent. It is in great demand, particularly for mixing with low-silica, direct shipping ores of inferior structure. Strangely enough, washing not only removes silica but also removes water from the ore. The concentrate is often lower in moisture than the crude ore because clean lumps drain drier than when they are coated with sand and silt.

Heavy media separation consists first in preparing a high density fluid of finely-ground, high-silicon iron and water. The percentage of silicon must be high enough to prevent oxidation and not so high as to make the metal nonmagnetic. The iron ore is crushed, washed and screened to remove the fine material. The gravity of the liquid is held at 3.2 and all particles of ore having a gravity higher than this settle to the bottom of the container and can be drawn off as a concentrate. All particles having a gravity less than 3.2 float to the top and are skimmed off. It is necessary to wash and screen both the concentrate and screened material to recover the high silicon iron, which is dewatered and cleaned magnetically to remove slime and sand and is ready to be used again.

Jigging was a method used for a while in iron ore concentration. It was used where ore of a wash type had pieces of silica too large to be washed away. Before jigging is done, the ore is crushed to about one inch in size and washed to remove the fine sand and silt. With jigging, the fine material is sifted out.

Drying plants have been operating on the Mesabi range and on the Cuyuna range. The Cuyuna has used it successfully as a beneficiation process. The drying operation simply removes some of the moisture, reducing shipping weight considerably.

The sintering operation removes all of the moisture, most of the ignition loss, and greatly improves the structure. Some ores are so fine or have such high moisture content that they cannot be economically shipped or used in the furnaces. By mixing these ores with coke and through the application of intense heat they are dried and fused so that they may be shipped and used. The sintering process is too expensive an operation, however, to be used extensively.

A more refined heavy media process is the Cyclone, which treats ores of fine sizes. Using a magnetic or ferrous-oxide pulp rather than ferro-silicon, it adds centrifugal force to gravity to increase the separation through the heavy liquid.

The flotation method, used mostly in Michigan, is a process where

the ore, in mixture with water, is placed in a tank which has air forced through it from the bottom. Chemical reagents are added which force the iron to stick to the air bubbles and rise with them. Impurities remain in the liquid. The frothy iron mixture is skimmed off and the impurities rejected.

Processing low grade ore has become increasingly widespread in the mining business in recent years not only as a conservation measure but also as a means of developing new sources of raw materials. Every large company is engaged in this activity.

Ore deposits are sampled and analyzed before digging starts. It is classified into grades or types. These reflect the amount of iron and other minerals present in the ore, the moisture present, and the physical characteristics such as coarse ore characteristics. After the ore is mined and the ore cars are loaded, they are assembled in the mine yard where they are sampled. Usually four cars of 150,000 pounds or more capacity constitute a sample, or sometimes five cars of 100,000 pound capacity. To sample a car, a knotted rope is thrown across the loaded car. Then a mine sampler takes a scoop of ore at each knot on the rope. This sampling is crushed and analyzed in the laboratory. The same number given to the sample from each car also is used as the way-bill number when the cars are turned over to the railroad. No matter where the car of ore is, it is readily identified as to grade. This greatly facilitates shunting of cars in the sorting yard.

The mining company's laboratory analysis of the samples is teletyped to the railway sorting yards before the train arrives there. The sorting yards are simple large switching areas a few miles from the docks. At the yards a train is assembled, containing the grade and amount of ore that has been ordered for a certain ore vessel already on the way up the lakes.

The long ore train goes from the sorting yards to one of the loading docks. A typical ore dock is a pier-like structure about 85 feet high, and 2,304 feet long. On top of it are railroad tracks directly above a series of steel and concrete pockets, each capable of holding 250 to 400 gross tons of ore. Total capacity of ore docks ranges from 44,000 to 153,000 gross tons of ore.

The ore train rides out over the dock and stops with each car above a pocket. The bottoms of the cars open and the ore flows by gravity into the pockets. It is important that the first car of ore to be dumped into the dock pocket be free running ore so that it will not clog the chute and delay a freighter several hours. Then the ore is layered in the dock pockets by grade and by structure. The physical characteristics or structure is important in this mixing because too much fine ore causes a considerable furnace loss through flue dust. Instructions must accompany each car to the loading docks giving the proper

dumping sequence so that there will be a layer of coarse and a layer of fine and a layer of high grade and a layer of lower grade ores.

Some mixing of ore is done right in the mine when a bank of an open pit is of varying analysis. Leaving the dipper door open, the shovel will comb the bank, permitting the ore to accumulate in front of the shovel before loading it. But most of the mixing is done in the dock pockets. This is engineered from the grading office at the mine. With the way-bill numbers as a key to the content of the train, the grading office issues switch orders to the dock, assigning each way-bill to a numbered block of pockets.

Ore freighters are assigned to either a block of pockets, if that makes up a cargo, or to a combination of blocks, to get the right grading for the cargo. When the dock superintendent dumps ore into a dock pocket, only one car of a sample is dumped into any one pocket. Since a pocket has about a five-car capacity, this means that five different samples would be in one pocket. That starts the mixing of the cargo load. It usually takes two pockets to fill a hatch of the ore carrier so that this also causes a greater uniformity of ore in each hatch. Now the ore vessel comes up beside the dock and its steel hatches, spaced 12 or 24 feet apart, are opened. Next, long steel chutes are lowered from the ore pockets into the hatches, and down the chutes flows the ore, filling an average vessel with about 12,000 gross tons in four to five hours.

This process is concerned primarily with open pit mines but underground mining affects only the manner of accumulating ore at the mine. Ore is stockpiled in the winter at underground mines. This stockpile is then mixed with ore direct from the shaft in the summer shipping season. In addition, the ore gets pretty well mixed in the frequent handling it receives in the mining process. In underground mines there is not apt to be the wide variation in ore samples from car to car as in open pit mining.

After a vessel is loaded, the grading department then sends a report to the mill which ordered the ore. An ore vessel can transport 400,000 tons of ore in a season. The ships can only operate about seven and a half months a year because part of the water route freezes during the winter. Incidentally, the ore is so heavy that the ships leave the dock with only about one-half the available cargo space filled. A completely loaded freighter would sink at the dock.

Taconite is a salt-and-peppery looking gray-green rock closely veined with irregular dark bands that are richer in iron than the lighter parts. A very small part of this rock is usable, containing from 25 to 35% iron, and most of it is waste. It is found along the three Minnesota iron ranges and in Canada, Wisconsin and Michigan. In a piece of taconite from the east-central Mesabi range, there are found

four main kinds of minerals; Iron oxides, 35%, Iron silicates, 20%, Iron carbonates, 5%, Chert, 40%. They are combined in the rock in an endless number of ways so that no two pieces have exactly the same composition. Of the four, the iron oxides are the only ones useful in the manufacture of iron and steel. Since they make up only about a third of the rock, it takes at least three tons of crude taconite to yield a single ton of usable product.

Iron oxides are found in two main forms and have one important difference. Magnetite, a fine-grained, black mineral, can be readily picked up with a magnet, while hematite or red rust is practically non-magnetic. In the commercially usable taconite of the Mesabi, nine-tenths of the iron oxide is in the form of magnetite.

About two-fifths of the rock is made up of chert, a fine-grained colorless quartz. Chemically, chert is composed of silica and is a waste product. The remaining minerals consist of iron silicates and iron carbonates occurring in colored needles, grains and patches. Both types of minerals contain iron, but it is difficult to salvage iron carbonates in processing and impossible to salvage iron silicates. They are waste materials as far as present methods are concerned.

Everything about taconite is as hard as the rock itself. The most successful method of drilling into the taconite is by jet piercing. This machine weighs 77,000 pounds and has a 50 foot derrick. It sinks a blast hole 40 feet deep, using oxygen and kerosene to create a flame of terrifically high temperatures—about 4300 degrees F.—which pierces the hole at an average of 18 feet per hour. Sprays of water quench and embrittle the particles of rock exposed to the flame and help carry them away. As long as the rock is uniform and not fractured, the method works very satisfactorily. Fracturing, or soft seams in the taconite, lets the heat and steam escape in all directions and causes trouble in drilling.

After a certain number of holes have been drilled to the desired depth, the holes are loaded with powerful explosives and blasted. This produces a large number of chunks too large to handle by the shovel and which must be broken by secondary blasting or by use of a skull cracker. A skull cracker is a large ball or iron cube which is lifted by a crane and dropped on the big chunks to reduce them in size.

When the taconite is sufficiently blasted, it is now ready to be mined. Mining is done by the open pit method in the same manner as the high grade and low grade ores. Loading is done by use of electric shovels. The ore is loaded into trucks or railway cars for transportation to the concentrating plant.

Trainloads of taconite rock from the mine are dumped into a large bin at the coarse crushing plant. A jaw-type crusher reduces the chunks to slabs eleven inches thick. Then a "coffee-grinder" type

crusher breaks the slabs to pieces about five inches in thickness. Nearly a half mile of belt conveyors are used to carry the crushed taconite through the two to four crushing plants. Vibrating screens remove the smaller particles, returning the larger oversize pieces for more crushing.

By now the taconite is about three-quarter inches and is fed into the rod mill. This mill consists of a rotating drum partly filled with tumbling steel rods. Taconite pebbles and water, fed in at one end, are pounded into a soupy, black mud that flows out at the other end. An intermediate separation is sometimes used, called "cobbing" where a series of magnetic separators rejects 35 to 40% of the taconite as worthless. The rest of the mixture, which is now a thick mud composed of tiny taconite particles and water, is ground finer by steel balls in the ball mill, until the finely ground taconite has the consistency of flour.

Concentrates leaving the ball mill are pumped to a classifier which separates the finer ground materials. What is coarse is returned to the ball mill for further grinding and fine material is pumped to the magnetic separators. Here the electromagnets draw the tiny particles of magnetite to the surface of a rotating drum while nonmagnetic particles drop away and are discarded as waste. By now the product is mostly magnetic but fragments of chert and silicates always manage to remain. Iron content is now very high, about 64%, while the remaining silica amounts to about 8%. As some of the iron in the rock cannot be picked up with a magnet, the waste that slips away carries most of these other iron minerals along with it and is actually about 8% iron.

The last steps in taconite processing combine the extremely fine particles that leave the separator into lumps. This is necessary in order to prepare the product for blast furnace use. Three different methods are used but the formation of pellets is the most popular. In this process, water is sucked by vacuum from the soupy, black concentrate flowing over the filter drum, converting it into a thick mud that will cake easily. The mud then enters a slightly inclined rotating balling drum. By the time it has tumbled and rolled to the far end, it has formed into an endless procession of round pellets. The pellets, about an inch in diameter, are very cohesive but heat treatment is necessary to make them hard and solid, ready for the rough handling they receive between the plant and the blast furnace.

The pellets are fed into the top of upright furnaces about 30 feet high. In passing downward through the furnaces, the balls come in contact with hot gases rising from heating chambers. The moisture is evaporated and the pellets heated at about 1800 degrees which forms a hard coating on the pellets. By the time they reach the bottom of the

furnace, the pellets are cooled and drawn off and conveyed to a loading hopper which drops them into railroad cars for shipping.

Other types of furnaces have been developed by different companies for the handling of fine ore material. A sintering method is used where coal and fine iron powder have been mixed and passed over heating chambers in long horizontal moving conveyors which form a substance that resembles clinkers.

In the nodulizing furnace the powdered material is rolled in a long drum-like furnace with coal-fired burners throwing flame and heat on the revolving material to form hard, dense nodules.

These processes are complicated and expensive. They use vast amounts of water, heat, power, and involve great plants and costly machinery. The product will be high in iron content and low in impurities and desirable in structure and form for furnace use.

One of the most important raw materials in the manufacturing of taconite concentrates is water. For every ton of concentrate made, seven tons of water is used. Water is used in nearly all of the operations from fine grinding through the magnetic separation. That is why concentrating plants are placed near a plentiful supply of water. To use water from a lake or stream is not nearly as simple as most people think. It required years of collecting data on temperatures, rainfall, relative humidity, streams and winds. Permission must be obtained from Conservation Departments and from people living on lake shores. The purchase of a great deal of land is involved. Dams must be built to hold waters at flood stage to be used in dry periods. Enormous tailing or waste basins must be built to hold the waste material from the plant. Since there are over three tons of sandy tailings produced for every ton of concentrate shipped, large areas are necessary to contain the wet waste. Experiments are also being carried on to determine the vegetation that will best grow on these basins to hold the fine materials from blowing away in high winds.

Electric power is one of the biggest factors in taconite concentration. Crushing and fine grinding are the biggest users of electric power. Motors of one thousand horse power are common. Fuel for heating furnaces where the pellets are burned is also another big item. Liquid oxygen for drilling is also costly. The prevention of dust which is always present when fine grinding is done is a task which requires the installation of complicated and expensive dust collecting equipment and ventilating machinery.

Reserve Mining Company and Erie Mining Company have had to build railroads from the range mines to Lake Superior. This involves the obtaining of right-of-ways and the building of the railroad as well as docks for loading the freighters. Oliver Iron Mining uses the previously built Duluth Mesabi and Iron Range Railway. The building

of plants, towns and schools for employees and their families, and miscellaneous other expenses are necessary and important factors in the taconite industry.

Reserve Mining has a vast deposit of magnetic taconite on the eastern tip of the Mesabi range. It is about nine miles long, averages 2,800 feet wide, and 175 feet deep at the thickest point. It is almost free of glacial overburden and surfaces of taconite are frequent. The ore body is known to contain at least one and a half billion tons of magnetic taconite which can be mined by the open pit method. This, when processed, will amount to one half billion tons of high grade ore, enough to supply ten million tons annually for the next fifty years. Reserve plans to expand to ten million tons per year which would mean the mining of thirty million tons of taconite annually. Their plant is at Babbitt, Minnesota. The pellet they ship contains about 62.5% iron.

A few miles northwest of Aurora, Minnesota, the Erie Mining Company has a taconite plant which produced 500,000 tons of pellets by 1954. Their process proceeds from the open pit mining where they jet pierce the hard taconite rock, to the concentrating plant, and the pellets are carried by railroad to Taconite Harbor, formerly known as Two Islands, where they are loaded on lake freighters.

Oliver Iron Mining Division of United States Steel Corporation is the largest operator on the Mesabi range. Their output exceeds the combined capacities of Aurora and Babbitt. In 1950, Oliver's Extaca experimental agglomeration plant was built. Its purpose was to provide data on the nodulizing of high grade ore and would help relieve the shortage of direct shipping ore. Techniques and personnel were developed to handle taconite concentrates.

In 1951, Pilotac, Oliver's experimental taconite concentration plant was under construction and completed in 1953. The Pilotac mine is the source of crude taconite which is mined, hauled to crushing plants, ground to flour-fineness and the iron bearing particles separated by electro-magnets. The taconite at Pilotac is particularly magnetic. Agglomeration sticks the fine iron ore concentrates together into sinter or nodules. The Oliver Iron Division agglomerates the concentrates produced at the Pilotac plant at its Extaca plant at Virginia. Pilotac is a "pilot" or first plant. It is an experimental unit. It is estimated that the capacity of this plant is 500,000 tons of concentrates a year to be produced from up to 2,000,000 tons of crude taconite rock. In 1955, Oliver processed three-fourths of all the ore it mined. Chemical laboratories are located at central points near the mines where 215 technicians sample, analyze and grade the millions of tons of ore which Oliver mines and ships each year from all its twenty-two mine operations.

Production from the Mesabi range should reach 6-7 billion tons a year by 1957. In 1954 the current yearly iron ore production from the Mesabi ran 60-70 million tons, while the Marquette, Menominee and Gogebic ranges each produced 4-5 million tons a year. In estimating the taconite reserves, it is realized that only a part can be used commercially. Some layers are rich in magnetite, while others have practically none. In some layers the minerals are rather coarse-grained and in others so fine that nothing can free the minerals from each other. The western 30 or 40 miles of the Mesabi range are almost without magnetite but along the eastern and central part there are two or three good-sized zones of fairly rich magnetic taconite. Therefore, while the taconite reserves are almost limitless, only these reserves from the richer magnetic layers and near the surface, will be used. Based on this conservative opinion, usable taconite reserves have been estimated at about five billion tons. This would be enough to produce 1.7 billion tons of concentrates which represents about as much iron as all the ore shipped in the history of the Lake Superior iron ranges.

The ranges of Wisconsin and Michigan have adopted new methods as well as the Mesabi range. The first of two plants designed to process the jaspery, iron bearing rocks of Upper Michigan is on the Marquette range. The methods used have been designed for processing iron bearing rock that is nonmagnetic. The eastern ranges are narrower and steeper than the Mesabi. More intense earth movements once tilted the rock layers of these ranges steeply on end. As a result, the ranges are narrower belts and smaller tonnages are available near the surface. Some are too narrow to mine by open pit methods. Some underground mining costs are roughly three to four times those of open pit operations and many of these steeper formations are not practical sources of raw material for manufactured iron ore at the present time.

Most of the iron oxide on these ranges is in the hematite. The magnetic separation process used on Mesabi taconite will not work on these rocks and other processes are usually more expensive. There are some localities, however, where the rock is richer in iron than Mesabi taconite and where grinding will be less expensive because the rock is softer. These ranges are close to their markets.

The most extensive type of iron bearing rock on the Marquette is called "jaspilite." It is judged by alternating bands of silver-grey hematite and a rust-colored quartz called "jasper." The hematite-jasper rock has some features that recommend it over taconite. It runs higher in iron and is easier to mine and crush because of its lack of silicates. Because of its coarser grain size, grinding need only be carried to 8-10 thousandths of an inch compared with the 3-5 thousandths of an inch required for taconite.

The Marquette range is probably the most important of the Michigan-Wisconsin ranges. The Humboldt Mine, operated by the Cleveland-Cliffs Iron Company for the Humboldt Mining Company, owned jointly by the Cleveland-Cliffs Iron Company and Ford Motor Company, is completing its second year of operation treating the low grade specular hematite ores of Michigan by froth flotation. The mine and concentrating plant are located west of Ishpeming on the Marquette range. This first unit produces about 250,000 tons of concentrate per year. This region has been the area of extensive underground workings which have shipped high grade ore. Since 1951 commercial beneficiation has been used on properties where high grade reserves were depleted. The second jaspilite plant built by Cleveland-Cliffs is at Republic, Michigan.

Flotation has been mentioned as being the process which involves the coating of the mineral with a film so that, upon coming in contact with an air bubble in a mixture, the coated particle attaches itself to the bubble and rises to the surface. With specular hematite, the chemicals used are mostly fatty acids from animal fats, vegetable sources, or forest products. They remain liquid at low temperatures. The difference in density between the iron and silica minerals accounts for the higher iron values in the finer sizes.

Other techniques, called gravity separation and density separation, rely on the great difference in weight between iron and silica. With the aid of special equipment, the hematite can be separated from the lighter silica minerals.

The Menominee range is hard to estimate. A number of its surface exposures are unsuitable, some too fine grained, too narrow, too lean in iron, too high in impurities or too thickly covered with glacial drift to be used. Therefore, though deposits of iron bearing rock over the whole range are quite large, most of them are unsuitable for commercial processing. Among the localities offering large open pit material is the Felch district north of Iron Mountain, Michigan. A small pilot plant was built by the M. A. Hanna Company to gain information about this area, but this plant was torn down and no plans have been made.

Most of the iron ore now mined on the Gogebic comes from the part located in Michigan, though the iron formation stretches about 45 miles into Wisconsin. The range is well explored, and it is known that large tonnages of iron bearing rock quite similar to taconite exist. However, the iron formation is steeply sloping so that the surface is narrow compared to the Mesabi. Only thin widths of the formation appear to be suitable for concentration. The eastern part of the range is heavily covered by glacial deposits. The expense of underground mining would be too great in this area. Its iron con-

tent is not predominantly magnetic and processing would be too expensive. The material is quite fine-grained so the Gogebic has none of the advantages of coarse grinding found in iron formations on parts of the Marquette and the Felch district.

America's steel mills are supplied by substantial tonnages of foreign ores. New mines in Canada and Latin America have begun shipments. The iron ore deposits in the area of the Labrador-Quebec boundary in Canada is the last known big undeveloped iron ore reserve in North America. There are about fifty proven deposits with varying tonnages in the Labrador-Quebec area. A great deal depends on the St. Lawrence seaway completion because of the need to get the ore to the consumers.

Far to the south in Venezuela is Cerro Bolivar, the richest iron deposit in the world today. United States Steel Corporation has Cerro Bolivar under contract for 100 years. Cerro Bolivar is a mountain—eleven miles long and one mile wide, jutting upward 2,000 feet, more than half of which is solid iron ore. Its tonnage has been placed at 500,000,000 plus, with grade averaging about 63% iron.

A number of other deposits in foreign countries also are being developed, principally by American steel companies. Bethlehem Steel Company's El Pao mine, operated by Iron Mines Company of Venezuela, is about 3,000,000 tons. In Peru, Marcona Mining Company is developing properties that will ship 2,000,000 tons annually. Sweden, Africa and other countries also are showing effects of the current widespread demand for ore.

Iron ore can serve only one purpose—to make iron and steel. It must be mined to be of any value. Minnesota ore, which helped create and expand America, has been responsible for the production of about 65% of our iron and steel. Many of these rich deposits have dwindled but the United States is fortunate in having mining men with vision and who understand the need for conservation.

Forty years ago when the Lake Superior area had great tonnages of high grade ore, men began to develop the huge supplies of low grade ores. By special processes they made the low grade materials into high grade ores. Over 376 million tons of high grade ore have been made from ores originally thought too poor to mine, conserving the high grade ores for the future. The capacity of the plants devoted to the concentration of low grade ores is limited, however, by the cost of investment, the ability of machines to produce and the length of the ore seasons. Underground mining operations have constant and uniform production but the cost factor is high. Today over sixty plants treat Minnesota's low grade ores which average more than one-third of the state's total ore shipments.

Continued success in the ore treatment processes means that today

the mining men produce ore from Minnesota's abundant supplies of taconite. Investment in commercial facilities to manufacture high grade iron ore from iron bearing rock is successful for three district iron ranges and a future possibility for others. The Mesabi's easily accessible reserves are large enough to judge it as the center of future developments but the Marquette range is also important because of its work on nonmagnetic sources.

The taconite industry on the Mesabi range has possibilities of going beyond the twenty million tons a year capacity from the three big commercial plants. Taconite is one of the chief factors in making up the difference between the expected growth of iron ore demand and the decline in output of Mesabi's natural ores. The costs of producing taconite must compare favorably with foreign competition.

Costs are a critical problem for taconite. Mining costs are very high as each ton of product must bear the mining costs of three or four tons of crude rock. In addition, power, fuel, and water requirements for processing steps are great. Only if all angles of cost are kept as low as possible can the taconite industry expect to be competitive with other sources of high grade ore. Technical advance can have a great effect on operating costs through the discovery of more efficient machines and methods. A lower tax than that for other ores helps keep expenses down for the taconite industry.

Iron ore production from the Lake Superior district will come from four main sources in the future. Based upon continued experiment and success, taconite may be the largest factor in this production. Low grade ores will continue to expand their present tonnage. Underground mines will be an increasing source of ore supply. High grade iron ores will be important but their position will be different from the past if they are conserved and used wisely. The success of low grade ores and taconite will not decrease the importance and advantages of the direct shipping, open pit ores.

It is very possible that with each additional year the taconite industry will continue to improve its competitive position. The tremendous amount of money spent on research and development and the intensive work carried on by the companies and institutions that made commercial taconite a possibility in the first place are reasons for optimism.

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A STUDY OF HIGH SCHOOL SCIENCE

A new approach for the teaching of high school science will be sought with the support of a grant of \$303,000 by the National Science Foundation to the Massachusetts Institute of Technology.

With a three-day conference at M.I.T. beginning today, leading scientists and secondary school educators are inaugurating a program which they hope will result in new teaching effectiveness and attracting more young people to the crucial field of science. Representatives of Harvard University, California Institute of Technology, Cornell University, the University of Illinois and Bell Telephone Laboratories are joining with M.I.T. faculty members and secondary school educators in the project.

"The Foundation has long realized the need of teachers of secondary school science for better textbooks, better materials, better instruction techniques," Alan T. Waterman, director of the National Science Foundation, said in announcing the grant. "Teachers need up-to-date tools to do a competent teaching job. We believe, however, that we must make a broad attack on the problem, rather than approach it on a bits-and-pieces basis."

New laboratory equipment, films, textbooks and even do-it-yourself laboratory kits for experiments at home are to be considered as possible means of exciting greater enthusiasm for science, especially in high schools where courses in physics and chemistry have begun to languish. But to begin with, the primary consideration is the question of what should be taught, according to Dr. Jerrold R. Zacharias, M.I.T. professor of physics, who is chairman of the steering committee organizing the project. Physics and chemistry are not static subjects and should be taught in a way that will enable students to comprehend exciting new developments, he explained.

Dr. James R. Killian, Jr., president of M.I.T., said: "It is now becoming recognized that the current fashion of blaming the shortage of scientists on the shortage of competent teachers in the secondary schools is not a wholly adequate explanation. The shortage of competent science teachers has a major part to play in our shortages, but there is the other factor that the teaching materials available to the teachers have not kept pace with the rapid advances in science and the standards it now requires."

"Secondary school teachers and college teachers of science and mathematics must join forces to devise new courses, new texts, new teaching aids which will eliminate outmoded concepts, inadequately defined units, lack of coherence and which instead will provide both teachers and students with more penetrating and richer scientific content."

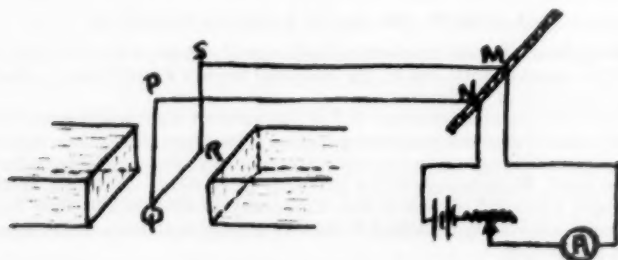
Signal Auto Light for highway safety when you are forced to stop provides a blinking red and yellow flash. The cord is plugged into the cigarette lighter socket and the light automatically flashes on and off. It can be put on any part of the stopped car by means of a rubber suction cup.

MEASUREMENT OF A MAGNETIC FIELD

JULIUS SUMNER MILLER

El Camino College, El Camino College, California

The force on a current-bearing conductor in a magnetic field is readily shown to be $F = BIL/10$ dynes, if B is in gauss, I in amperes, and L in cm. If, then, F , I , and L are measured it is simple to compute B .



Bend a length of heavy Cu wire into a square U , such as $PQRS$, with bends at P and S so that lengths PN and SM are easily flexed. That is, so the U -frame hinges at M and N . A horizontal rod supports the conductors. View the horizontal member QR , which lies between the poles, with a reading telescope. Note the deflection of the loop with an appropriate current. To find the force necessary to produce the same deflection load the wire QR with small weights, such as little wire loops. These are then weighed on an analytical balance.

Before measuring the field between the poles of a horseshoe magnet, say, *speculate* on the field strength. Is it 10, or 100 or 1000 gauss? Or is it nearer 10^4 or 10^5 gauss? It is surprising to discover how very little *people* known about this! And by *people* I guess I mean physics teachers!

NEW DRUG LOWERS BLOOD PRESSURE AND ANXIETY

Another drug to combat high blood pressure, and said to offer advantages over older drugs, was announced by Dr. Karl J. Brunings, director of chemical research for Chas. Pfizer & Co., Inc., Brooklyn, N. Y., to the American Chemical Society. The new drug, trade-named "Moderil," reduces blood pressure by cutting communications between selected nerve centers and the arteries they serve. It is extracted from the Indian snake root, *Rauwolfia*, source of many of today's tranquilizing drugs. The new drug seems to control anxiety and tension as well as high blood pressure, Dr. Brunings said. This relief of anxiety often associated with high blood pressure is believed to be an added advantage of the drug. "It has been given to hundreds of patients with hypertension and anxiety and has been found to be highly effect," it was reported.

COLOR BALANCING BY SIMULTANEOUS LINEAR EQUATIONS

CLYDE B. ANDERSON

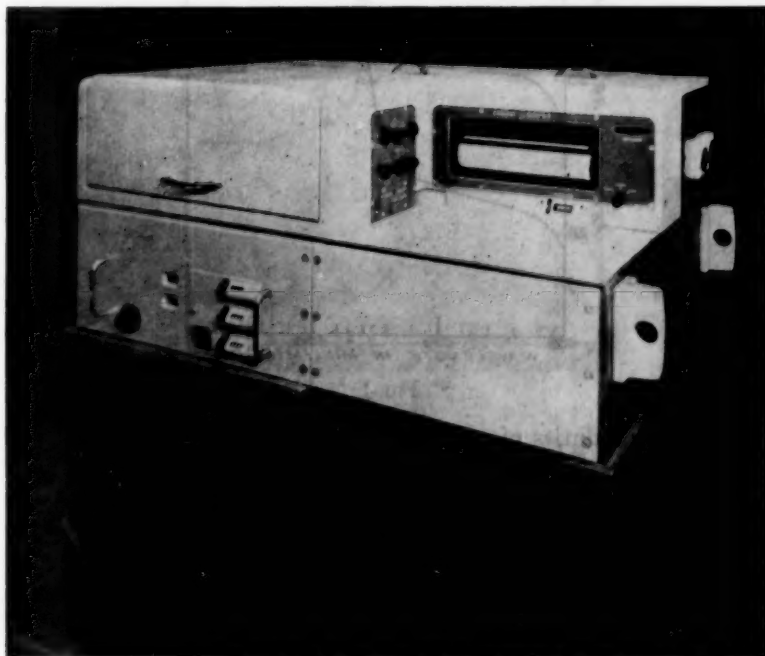
Dow Chemical Co.

AND

LESTER H. SERIER

Central Mich. College, Mount Pleasant, Mich.

Teachers of mathematics are always on the lookout for direct applications of elementary mathematics to industry. An illustration which involved the solution of simultaneous equations appeared in the *Mathematics Teacher* of March, 1955.¹ This illustration suggests another interesting and practical use of simultaneous equations and at the same time demonstrates the use of graphical analysis.



Reproduced by courtesy of the General Electric Company Instrument Department

The General Electric Recording Spectrometer

¹ Hicks, Charles R. "Two Problems Illustrating the Use of Mathematics in Modern Industry," *The Mathematics Teacher*, March 1955. Pages 130-132.

Plastics manufacturers face the problem of color control in producing successive batches of their product. To assure consistency of color, technicians, known as color formulators, determine and adjust the color recipe used to color the plastic. Among the devices used by these technicians is an instrument called the General Electric Recording Spectrophotometer.

Although the machine does not eliminate the need for men highly trained in the theory of color vision and color measurement, men who are needed to design and control the variables built into the spectrophotometer, it is possible to train technicians to use this instrument

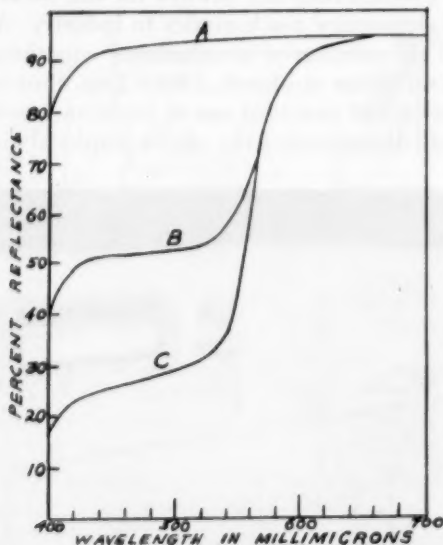


FIG. 1

in the routine duties of color mixing and color matching. For this work the technician must have a knowledge of elementary high school algebra.

When Newton discovered that white light is made up of a mixture of visible radiant energy and that most objects appear colored because they absorb some varieties and reflect other varieties of radiant energy, he made possible the development of the science of color mixing.

Almost everyone has performed the experiment with the prism, of dispersing a beam of white light into the rainbow of colors called the visible spectrum. These colors lie along a continuum from a violet with a wave length of 400 millimicrons to red with a wave length of 700 millimicrons.

The experiment shows that white light contains all the colors of the spectrum. Our eye compares the appearance of a sample color with white light. If we look at a white object, all of the colors of the spectrum are reflected back to our eye, and we agree it is visually white. If we look at a black object, all the colors of the spectrum are absorbed, and no color comes back to our eye. The resultant absence of color we agree is visually black.

Let us now consider how colors are formulated. In figure 1 curve *A* is the spectrophotometric picture of a white pigment. A white pigment reflects all the colors of the spectrum to our eye. The addition of a

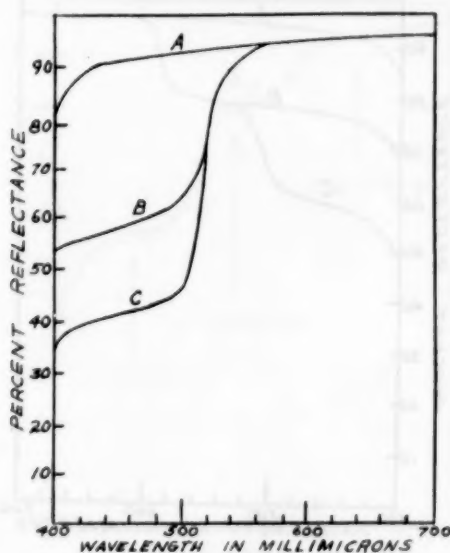


FIG. 2

small amount of red pigment removes all of the spectrum except red; that is, the pigment removes all the violet, blue, green, yellow, and orange colors, changing the graphic picture to a curve similar to *B*. A higher concentration of red pigment results in a curve such as *C*. Note that not only the left hand plateau is lower, but the drop in the curve takes place at the same point, namely the wave length of the red pigment used.

Now consider figure 2. Beginning with a white pigment, curve *A*, add a yellow pigment. Yellow removes approximately the first third of the spectrum and produces the result shown in curve *B*. If a higher concentration of yellow is used, curve *C* results.

Let us now formulate an ivory color. In figure 3 curve *A* represents

the white pigment. Adding red pigment removes the first two-thirds of the spectrum resulting in curve *B*. The addition of yellow removes only the first third of the spectrum. The resulting curve *C* represents an ivory color. The heights of the plateaus 1, 2, and 3 are controlled by the concentration of the respective pigments added.

The actual method makes use of the two-constant theory² for the calculation of opaque pigmented materials. This theory, developed with the aid of differential equations, begins with the assumption that the optical properties of a given pigment can be described by two constants, μ and p , called the absorption and scattering coefficients,

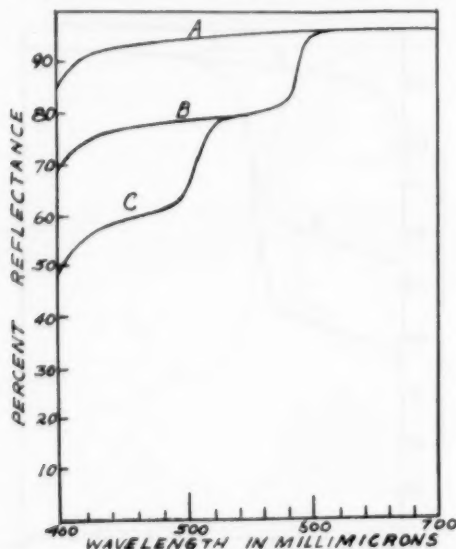


FIG. 3

respectively. These coefficients are a function of the wave length of light (λ) and are determined and catalogued for the use of the technician. The equation of importance for the technician, derived from this theory is:

$$\theta = \frac{C_1\mu_{1\lambda} + C_2\mu_{2\lambda} + C_3\mu_{3\lambda} + \dots}{C_1p_{1\lambda} + C_2p_{2\lambda} + C_3p_{3\lambda} + \dots} \quad (1)$$

θ_λ is the reflection value at wave length λ ; C_1, C_2, \dots are the concentrations of the various pigments used in the mixture; $\mu_{1\lambda}, \mu_{2\lambda}, \dots$; $p_{1\lambda}, p_{2\lambda}, \dots$; are constants obtained from the above basic equation and catalogued for the use of the technician.

² For a complete discussion of this theory the reader is referred to Saunderson, J. L. "Calculation of the Color of Pigmented Plastics." *Optical Society of America*. Dec. 1942, pages 727-736.

The instrument used by the technician is the General Electric Recording Spectrophotometer. Operation of the instrument is very simple. The operator inserts the sample and standard color in their respective holders, places the recording paper on a revolving drum and flicks a switch. The resulting curve is a measure of the per cent of reflectance of light from the sample as compared to a nearly 100% reflectance point of the standard white used, at a particular wave length λ . This complete curve is automatically drawn in fifty-four seconds.

The formulator's function is to determine the concentration of pigments needed to match the standard colors desired. He has at his

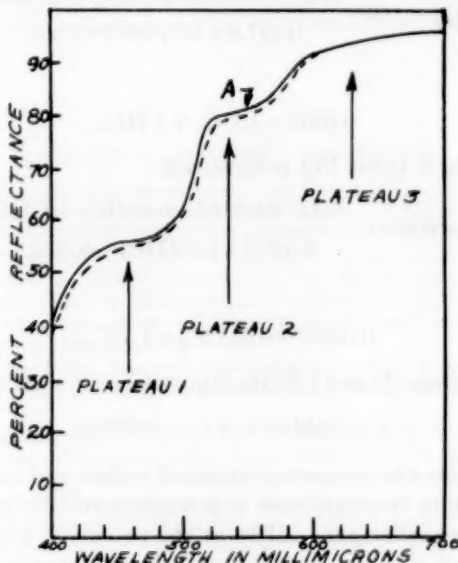


FIG. 4

disposal a catalogue of coloring agents with their proper constants and also a library of the spectrophotometric curves of the standard colors he wishes to duplicate.

The following example, an actual case taken from industry, illustrates how the color formulator uses algebra to match a standard color curve. In figure 4 let curve *A* be the one to be duplicated. A sample of the color being determined is placed in the spectrophotometer. The dotted curve is the graph of this sample. As can be seen by the graph there are three marked plateaus. For color adjustment one pigment controls each plateau. Since the white portion of the curve already matches, only two pigments are necessary to establish a color match.

The plateau between 420 and 500 millimicrons can be controlled

by a yellow pigment, and the plateau between 500 and 600 millimicrons by a red pigment. Referring to our catalogue of pigments we find the yellow pigment and the red pigment whose scattering and absorption coefficients are known at the wave lengths 460 and 540 millimicrons. From the standard curve we know the per cent reflectance we desire at 460 millimicrons and at 540 millimicrons, namely 56.3% and 80.6% respectively.

Referring to equation (1) and our catalogue of pigment constants we have at the check point 460 millimicrons,

$$\theta_{460} = .160 = \frac{0.327 \times 0.00920 + 2.31C_Y + 2.24C_R}{0.327 \times 1 + C_Y \times 0 + C_R \times 0}$$

from which

$$0.0493 = 2.31C_Y + 2.24C_R \quad (2)$$

and at the check point 540 millimicrons,

$$\theta_{540} = 0.0353 = \frac{0.327 \times 0.0105 + 0.0231C_Y + 1.43C_R}{0.327 \times 1 + 0.224C_Y + 0.204C_R}$$

from which

$$0.00807 = 0.0152C_Y + 1.42C_R. \quad (3)$$

Solving equations (2) and (3) simultaneously we obtain

$$C_Y = 0.0160 \text{ and } C_R = 0.00551.$$

By adding the above concentrations of yellow and red pigments to our known white concentration it is mathematically possible to obtain the desired reflectance values at the two given wave lengths.

As an extension of the above example let us suppose that the sample curve differs from the standard curve at the plateau between 620 and 700 millimicrons. We have then only to choose another check point, say, a white at 640 millimicrons, and determine a third equation θ_{640} . We then have three equations in three unknowns whose solution will yield the correct concentrations of red, yellow, and white pigments.

Since three figure accuracy is generally sufficient, slide rule calculations are acceptable.

The name "Color Balancing" is quite appropriate for this procedure. Since the red acts in both areas, i.e., the second plateau as well as the first plateau area, any adjustment in the concentration of the red has an effect in the yellow area (Plateau number 1). The necessary condition for balance in both areas is given by the simultaneous linear equations.

For the past several years the authors of this article have been training men for positions as color formulators. In order to qualify for training in this field, one must be a high school graduate with credits in high school algebra and high school physics. Men with these qualifications are given short refresher courses in algebra and physics after which the technical formulator training is given. Classes take place during working hours at company expense. Successful completion of the course results in a better job and more pay.

This article reveals, therefore, a simple application of elementary mathematics to an industrial process. Those men who had training in high school algebra were adequately equipped to deal competently with the spectrophotometer as it affected the manufacture of colored plastics.

DERTHICK SUCCEEDS BROWNELL

Lawrence G. Dertthick was sworn in today as Commissioner of Education, Department of Health, Education, and Welfare. He was appointed by President Eisenhower on November 28, 1956, to succeed Dr. Samuel M. Brownell, resigned. The appointment is subject to confirmation by the U. S. Senate.

Secretary Marion B. Folsom administered the oath of office in a ceremony at the Department of Health, Education, and Welfare, attended by senior officials of the Department and the Office of Education, Members of Congress, and representatives of national organizations.

Mr. Dertthick has had a long and distinguished career in education as teacher and administrator and as a member and officer of national educational organizations.

Prior to his appointment as Commissioner of Education, he was superintendent of the Chattanooga, Tennessee, public schools since 1942. He served as chief of the Education Branch, Office of Military Government of Bavaria, 1948-49, on leave of absence from his Chattanooga position. He was assistant superintendent in charge of instruction of the Nashville public schools from 1939 to 1942, and professor of education at East Tennessee State College from 1935 to 1939.

WHITE CRAB SEEN IN OREGON SECOND TIME IN EIGHT YEARS

A white Dungeness crab, only the second one seen in some eight years, has been brought into the Shellfish Laboratory of the Oregon Fish Commission here. The crab appears normal in every respect except its lack of coloration. It is alive and being kept in the aquarium at the laboratory.

Biologists hope to find out if the abnormality carries over in the new shell after the crab molts. Crabs must shed their shell periodically in order to grow. Molting usually occurs annually in larger crabs during fall months in Oregon waters.

This entirely white, male crab was brought to the Shellfish Laboratory by commercial fisherman George Zinserling from Nehalem Bay.

Biologist Lowell D. Marriage, who has been affiliated with crab and other shellfish research for the fish commission for the past eight years, stated that he has run across only one other white crab on the Oregon coast. The other "freak" was seen at Newport several years ago.

DIVISIBILITY TESTS

WILLIAM R. RANSOM

Tufts University

Tests for divisibility by 2, 3, 4, 5, 6, 8, and 9 are often taught in arithmetic. For divisibility by 7, it is quickest to actually divide by short division. Nevertheless, it is interesting to have a trick method by which such a test can be made.

Here is an example of such a method: use a succession of cycles, in each of which you cut off the last digit and subtract its double from the number that is left. For example, take 151711, thus:

If you come out with a zero or a number divisible by 7, the original number was divisible by 7; otherwise, not.

$$\begin{array}{r}
 151711 \\
 \underline{2} \\
 1516.9 \\
 18 \\
 \underline{1} \\
 1498 \\
 16 \\
 \underline{1} \\
 133 \\
 6 \\
 \underline{7} \\
 7 \checkmark
 \end{array}$$

The theory underlying this test may be explained in different ways. One is that what you have done is really to subtract multiples of 21, which reduces the number each time by a multiple of 7.

A more interesting explanation to offer is algebraic. At any stage the original number or one of the remainders can be described as $10a+b$. Now $10a+b$ and $20a+2b$ are either both or neither divisible by 7, and the latter can be expressed as $21a-(a-2b)$.

Since $21a$ is certainly divisible by 7, it follows that the divisibility in question depends only upon the divisibility of $a-2b$, which is what we calculate at each stage of the testing.

This theory can be extended to give a similar test for divisibility by any prime, P . P must end in either 1, 3, 7, or 9, and the respective prime multiplied by 1, 7, 3, or 9, will end in 1.

Suppose we have a prime, P , greater than 9, that ends in c , ($c=1, 3, 7$, or 9), and the multiple MP ends in 1, M being 1, 7, 3, or 9, always less than ten. Then $MP=10k+1$, whence $(10k)=(MP-1)$.

If the number to be tested is $10a+b$, as above, its divisibility is the same as for $k(10a+b)$ which can be written $(10k)a+kb$, which by substitution becomes $(MP-1)a+kb$, or $MP-(a-kb)$. Since MP is certainly divisible by P , the question turns on the divisibility of $a-kb$.

For example, if the prime is $P=37$, we have $3P=111$, so $k=11$. Then to test for divisibility by 37, cut off the last digit and subtract eleven times its value from the number that remains. Thus, to test 4588, we take 458 minus 88, and get 370, so 4588 is divisible by 37.

We live in an age of science, but not a scientific age.

AN AID IN SKETCHING PARABOLAS, WITH APPLICATIONS TO INTERPOLATION AND EXTRAPOLATION¹

S. I. ASKOVITZ

Albert Einstein Medical Center, Philadelphia, Pa.

INTRODUCTION

In mathematics and the related sciences, it is generally desirable that the numerical analysis of a problem be accompanied by a diagram wherever possible. In many instances, plotting a series of points directly from the equation of a curve may be a practical procedure, although this soon becomes rather laborious. A rough sketch often suffices as a visual aid, but is rarely precise enough to be useful as a check on the algebraic solution.

The ordinary parabola arises in a great variety of elementary applications, and it would seem worthwhile to have a rapid method for sketching this curve with a minimum of effort. The present article describes how the method of advancing centroids,²⁻⁷ developed some years ago to simplify the statistical analysis of graphic data,⁸ has been adapted to this purpose.

METHOD

Let us assume that a series of equally spaced vertical lines is available, and take three points L , M and N , located on alternate lines, as shown in Fig. 1. It is desired to sketch the parabola, with axis vertical, passing through L , M and N . Additional points on the curve to the left or to the right of the three given ones, and on equally spaced vertical lines, may be obtained as follows.

First, draw the straight line LN and note the intersection of this line with the two intermediate vertical lines at T and U . (It is not necessary to mark these points or to label them.) Next, draw the straight line through M and T and extend it to the left until it meets the proper vertical line,⁹ at K . Similarly, extend MU as far as the point P .

¹ From the Ophthalmology Research Laboratory, Northern Division. This work was supported by a grant from the Weinstock Fund.

² Askovitz, S. I. "Rapid Method for Determining Mean Values and Areas Graphically," *Science*, 121, pp. 212-213, February 11, 1955.

³ Arnsted, E. "Grafisk beregning af middelværdier," *Ingeniøren*, 32, pp. 654-655, August 6, 1955.

⁴ Askovitz, S. I. "Graphic Determinations of Mean Values," *Science*, 122, p. 973, November 18, 1955.

⁵ Askovitz, S. I. "Mean Rates of Change and Least Squares—Interpretations and Rapid Graphic Methods," *Journal of Applied Physiology*, 8, pp. 347-352, November 1955.

⁶ Sher, I. H. "Two Methods for Obtaining Least Squares Lines," *Science*, 123, pp. 102-104, January 20, 1956.

⁷ Askovitz, S. I. "Mean Rate of Change and a Graphic Method for its Evaluation," *Science*, 123, pp. 507-509, March 23, 1956.

⁸ Mellette, H. C., Hutt, B. K., Askovitz, S. I., and Horvath, S. M. "Diurnal Variations in Body Temperatures," *Journal of Applied Physiology*, 3, pp. 665-675, May 1951.

⁹ I.e., The second vertical line to the right of the Y -axis in Fig. 1.

Then K and P will also lie upon the parabola. Points further to the right or to the left may be obtained just as readily. For example, NV is extended to obtain the point Q , and LS to the point J . This procedure may evidently be repeated as many times as necessary.

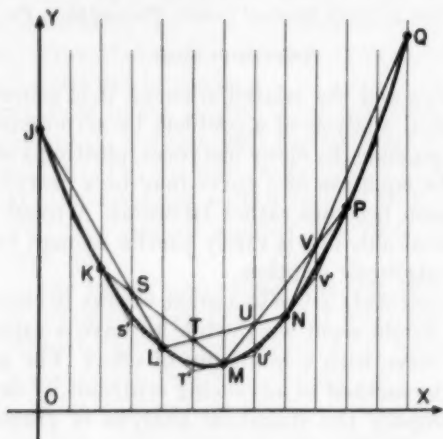


FIG. 1

We may now apply the familiar property of parabolas, that the tangent at any point is parallel to any chord bisected by the axis through the point of tangency. Thus, since the vertical line (axis) through M bisects the chord LN , the tangent to the curve at M would be parallel to LN . By drawing $T'U'$ parallel to LN , $U'V'$ parallel to MP , $T'S'$ parallel to MK , and so on, we can have quite readily a sufficient number of guide line tangents to allow a fairly accurate sketch of the parabolic arc JMQ .

PROOF

Take any parabola and draw four uniformly spaced transversals, A_0A' , B_0B' , C_0C' and D_0D' , all parallel to the principal axis, cutting the curve at points A , B , C and D , respectively (Fig. 2). Also, draw the line E_0E' halfway between B_0B' and C_0C' . Then E_0E' will bisect the chord BC . Since E_0E' is also midway between A_0A' and D_0D' , it will also be true that E_0E' bisects the chord AD .

Now, using the property of parabolas stated previously, the tangent at E will be parallel to the chord BC . Similarly, the tangent at E will be parallel to the chord AD . Therefore, BC and AD will be parallel to each other.

Draw the lines AC and BD , intersecting at point F . By similar triangles, it is seen that $AF:FC = AD:BC = 3:1$. The similarity of

the triangles follows from the fact that the corresponding angles are equal, and the 3:1 ratio is evident by inspecting the projections of AD and BC upon the horizontal axis. Therefore, the intersection F must fall upon the ordinate EE' . This is the property employed in the graphic construction outlined earlier.

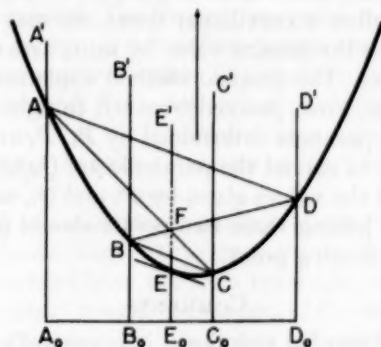


FIG. 2

INTERPOLATION

Let us inquire into the possibility of locating the point N which falls on the vertical grid line midway between the grid lines containing points M and P , having been given only the points L , M and P of the parabola shown in Fig. 1. The technique is straightforward. We merely draw MP , note the appropriate intersection point U , and extend LU to N .

Suppose now that K , M and P have been given on the curve, and that it is desired to interpolate for either or both of the missing points L and N . Join KM and MP , and note the intersection points with the appropriate ordinates at T and U . Extend TU to L and N .

The latter procedure may be applied to the points L , M and N of Fig. 1 to locate points of the parabola on the ordinates through T and U . However, an alternative technique (not shown on the diagram) has the advantage of not requiring any additional vertical lines. Let W be the midpoint of LN and let G be the midpoint of MW . Then NG and LG will intersect the ordinates through T and U , respectively, at a point on the parabola.

EXTRAPOLATION

An interesting application of extrapolation along parabolic arcs is to be found in laboratory experiments where daily observations on some variable quantity are charted, but with the values for certain

dates missing because of week-ends or holidays. The problems of curve-fitting and statistical analysis are often considerably simplified when the points graphed are at uniformly spaced time intervals.

Let us assume points P_1, P_2, \dots, P_6 , representing daily recorded values for one week, then a day on which no observation was made, followed by another series of data Q_1, Q_2, \dots, Q_6 , etc. Where the points seem to follow a curvilinear trend, we may usually obtain a better estimate for the missing value by using arcs of parabolas than with straight lines. The graphic method explained earlier may be used to advantage. First, proceed from left to right to find the "next point" P_7 on the parabola determined by P_4, P_5 and P_6 . Then work from right to left to extend the parabolic arc $Q_3Q_2Q_1$ to Q_0 .

The average of the values given by P_7 and Q_0 , or the midpoint of the line segment joining these two points should provide a suitable estimate for the missing point.

COMMENTS

In this type of graphic technique, it is generally not necessary to draw in all of the construction lines. A short dash to mark each needed intersection point should be adequate. On Fig. 1, instead of the entire segment LN , small portions near T and U will suffice.

Parabolas with horizontal or oblique axes may be sketched by the same method, with minor modifications.

To interpolate or extrapolate, in accordance with the second-degree equation, it is not necessary to draw any curve at all. The graphic methods provide the required points by straight-line constructions alone. Analogous techniques have been worked out for the graphic extension of third and higher degree curves.

Extraclass Activities in Aviation, Photography, and Radio for Secondary School Pupils. By Willis C. Brown. Office of Education Bulletin 1956, No. 11. 48 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 25 cents.

How can schools help meet pupil needs in the three areas of aviation, photography, and radio which are especially important to modern industrial and technical life?

This bulletin deals with three selected extraclass activities important to the Nation's scientific and technological progress and with their place in the modern secondary school. It reviews and highlights good practices in these three fields so that schools now having programs may be able to improve them and those having none may be stimulated to start them.

A great many secondary schools are today carrying on club activities of the kind described in this bulletin, but many more could well consider doing so as a means to help identify pupils having special interests and aptitudes. Further, these schools might well discover that the same activities could motivate formal classroom interest and achievement in science, mathematics, and industrial arts.

FROZEN SOIL IN THE LAND OF THE SOVIETS

H. PHILLIP BACON

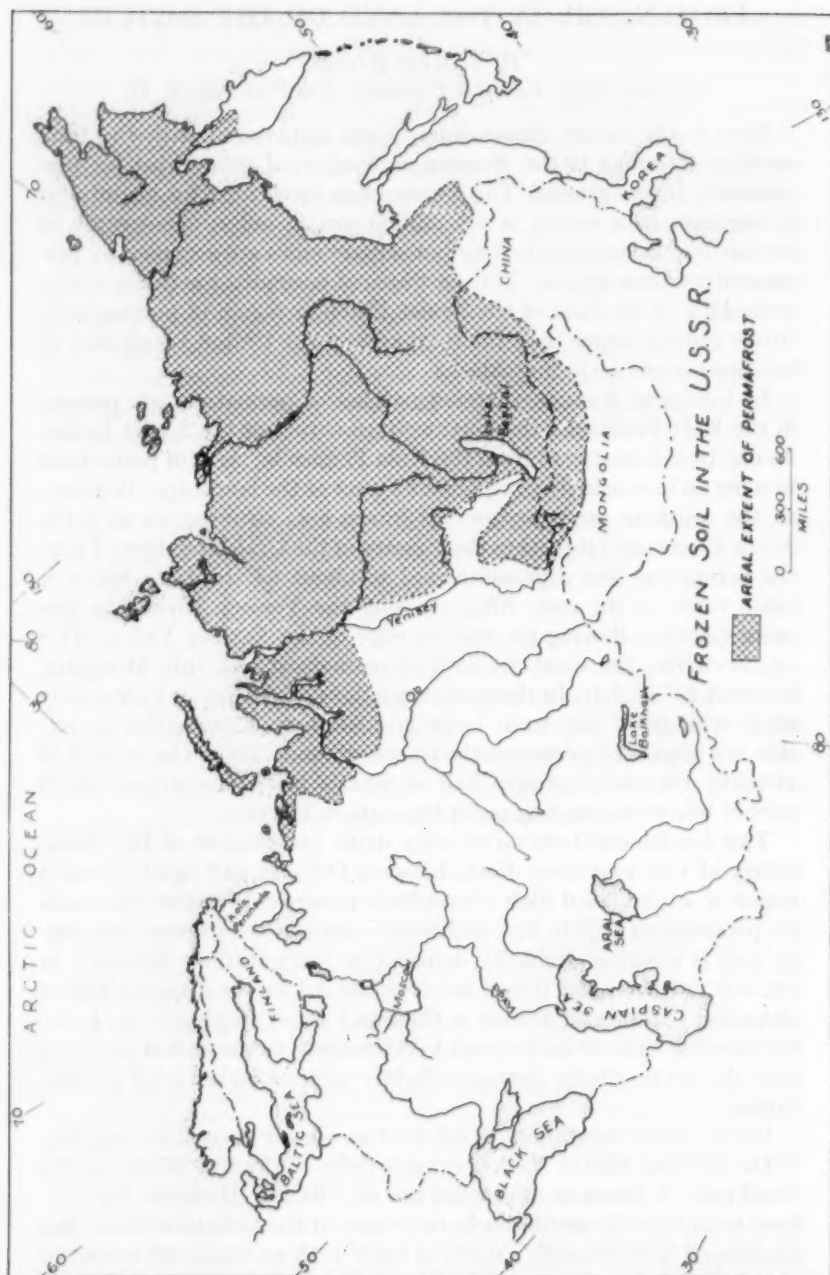
Teachers College, Columbia University, New York City, N. Y.

Rare is the Soviet citizen who is not acquainted with the term *merzlota*. *Merzlota* is the Russian equivalent of permafrost, or permanently frozen ground. The Russian has good cause for his interest in *merzlota*. In a nation of 8.6 million square miles, one-seventh of the earth's surface, nearly 4 million square miles are occupied by permanently frozen ground. This vast area of permafrost actually covers some 47% of the land of the Soviet Union, a region of permanently frozen ground larger than the total area of the United States and all her possessions including Alaska.

In European Russia, scattered patches of permafrost are present in the Kola Peninsula, the northwestern corner of the Soviet Union. As one travels eastward from the Kola Peninsula, signs of permafrost become an increasingly conspicuous aspect of the landscape. In general, the southern boundary of this frozen area corresponds with the Arctic Circle until it reaches the vicinity of the Ural Mountains. There the permafrost line dips southward to about 63° N. Lat., where it again turns to the east. After crossing the Yenisey River, the line swings south following the eastern edge of the Yenisey Valley. This course carries the southern limit of permafrost well into Mongolia, to about 50° N. Lat. In the eastern portions of the Soviet Union, only small sections of the Amur basin and southern Kamchatka lie outside the region of permanently frozen ground. Thus, the subsoil of virtually the entire eastern half of Siberia has temperatures which remain below the freezing point throughout the year.

Two fundamental characteristics strike the student of the climatology of this vast area. First, between October and April, this is a region of unparalleled high atmospheric pressure. In winter, barometric pressures of 30.5 to 30.7 inches are common occurrences. Secondly, this is a region decidedly deficient in precipitation. Sagastyr, in the delta of the Lena River, receives but 3.3 inches of precipitation annually. Olekminsk, almost a thousand miles south on the Lena, receives less than 10 inches, and Verkhoyansk, to the east of the Lena near the Arctic Circle, averages slightly under 4 inches total precipitation.

Under these conditions develops the almost incredible frigidity of the Siberian winter. Verkhoyansk's claim to the title of the earth's "cold pole" is based on a recorded low of -94.4°F. However, Oymyakon, located to the southeast in the valley of the Indigirka River, has challenged Verkhoyansk's mark of fame with an unofficial record of -115.8°F. These temperatures, of course, are extremes. Nevertheless,



mean monthly temperatures are unusually low. In nearly all parts of eastern Siberia continuous frost lasts for 7, 8, and even 9 months of the year and midwinter temperatures tend to remain continually below zero. Verkhoyansk, for example, has 5 months in which the mean temperature is well below zero and 231 days with temperatures below the freezing point. Everywhere in the permafrost region winters exceed summers in length and intensity.

Station	Mean Temperatures (°F.)												Av
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Olekminsk Alt. 495'	-26	-17	-2	24	44	60	67	59	46	24	-8	-19	21
Verkhoyansk Alt. 330'	-58	-48	-22	8	35	54	59	51	36	6	-34	-52	2.9
Yakutsk Alt. 330'	-46	-35	-10	16	41	59	66	60	42	16	-21	-41	12.2

Mean annual temperatures in the permafrost region are below freezing. Under these conditions, then, summer heat is not sufficient to counteract the penetration of cold waves which are sent into the earth each winter. The lower the annual temperature, the deeper will be this penetration of cold.

Permafrost is absent in eastern Siberia only in the lower Amur basin and in southern Kamchatka. These, too, are the only areas of eastern Siberia that receive more than a very limited total amount of precipitation. Maximum precipitation occurs in July or August over most of Siberia. In all parts of the permafrost region winter precipitation is very light. The resulting snow cover is frequently less than 4 inches in its deepest places. The combination of low temperatures and thin snow cover explains the extensiveness of the Soviet permafrost region.

Station	Precipitation (in inches)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Olekminsk	0.4	0.3	0.2	0.3	0.8	1.1	2.0	2.0	1.1	0.8	0.4	0.4	9.8
Verkhoyansk	0.2	0.1	0.0	0.1	0.2	0.5	1.2	0.9	0.2	0.2	0.2	0.2	3.9
Yakutsk	0.9	0.2	0.4	0.6	1.1	2.1	1.7	2.6	1.2	1.4	0.6	0.9	13.7

Vegetative and snow cover, as well as quantity of ground water, will, of course, accelerate or retard the development of permafrost and the depth it may attain. Permafrost in the Soviet Union is found in both the relatively barren tundra and in the coniferous *taiga*. As might be anticipated, the areas of deepest penetration of permafrost are found in the tundra regions. Near Nordvik, in the tundra of north-central Siberia, the layer of permafrost is estimated to be about 2000

feet thick. On the mainland opposite Vaygach Island, again in the tundra, a test borehole passed through 735 feet without reaching unfrozen subsoil. Apparently the total depth of permafrost in this area is exceedingly great, for at 735 feet the temperature in the borehole was still 9 degrees below freezing. Near Skovorodino, in the larch forests of the upper Amur Valley, the layer of permafrost is considerably less than in the tundra regions. There the average depth is about 160 feet. In still other portions of the southern *taiga*, the permanently frozen subsoil is much thinner, in places averaging only 3 to 6 feet.

A litter of pine needles, such as is typically found on the floor of the Siberian *taiga*, helps keep the soil from freezing as rapidly and as deeply as in the less protected soil of the tundra; however, it cannot prevent its ultimate freezing. Soil freezing usually begins to form in a cleared or burned-over area 2 to 3 weeks before it begins in a coniferous forest. Furthermore, permafrost develops in coniferous stands 2 to 3 weeks before it will begin in a hardwood stand. Maximum depth of freezing is frequently 3 to 4 times greater in open areas than in coniferous forests and, similarly, the depth of freezing is 3 to 4 times greater in coniferous forests than in hardwood forests.

Wind movement is consistently low in hardwood forests; thus, little drifting occurs and the snow is more evenly distributed over the forest floor. Also, hardwoods appear to intercept far less snow than a coniferous forest, which accumulates much of the limited snowfall of the *taiga* region on the branches of the trees. Thus, snow is not only distributed more evenly in a hardwood forest, but there is greater opportunity for the accumulation of a deeper insulating layer of snow on the floor of the hardwood area. In the tundra regions of the coast and the Central Siberian Plateau, snow cover is easily swept off the comparatively level surface leaving the ground open for the deeper penetration of cold waves.

It has also been found that permafrost develops most rapidly in soils that are low in humus content. Tundra soils and the infertile podzol soils of the *taiga* are notably deficient in humus.

It seems quite evident, then, that conditions for the formation of permafrost are ideal in the eastern half of the Soviet Union. There is a region of intense and long lasting cold, thin snow cover, tundra and coniferous vegetation, and soils deficient in permafrost retarding humus.

The development of permafrost presents some interesting, and at times amazing, results. The upper surface of the permanently frozen layer is called the permafrost table. Its contour is frequently quite irregular. The irregularity of the permafrost table is largely dependent upon variations in soil cover, ground water, exposure to the sun, and

the conductive quality of the soil. In places the permafrost table may be found at the surface of the earth, in other places it may be many feet below the surface.

The term "active zone" is used to describe the layer of ground above the permafrost table. It is "active" because it may be frozen or unfrozen depending upon seasonal changes in temperature. It is the changes that occur in the active zone that are the source of phenomena associated with permafrost.

Water expands 10% in volume when it becomes ice. As the frozen layer creeps downward through the active zone toward the permafrost table, the increased volume of ice creates pressure upon remaining ground water trapped between the two frozen and impermeable layers. As freezing continues in the active zone, the pressure of the water eventually becomes greater than the resistance of the upper frozen layer and the ground domes upward.

In some cases these domes of frozen soil swell to heights of 300 feet with perimeters of 3000 feet. Such great expansion is not fully explained by the 10% expansion of water in freezing. The explanation seems to lie in the manner by which ice crystals grow in freezing soil. Rather than freezing uniformly throughout the soil, ice crystals develop into lenses, or layers of ice, in the active zone. Trapped ground water is pulled up through the soil above the permafrost table to form these layers of ice lenses. They continue to increase in thickness and in number as long as ground water is available during the freezing process. The result is a multi-layered series of ice lenses, which at times cause as much as a 60% expansion of the soil.

From time-to-time the pressure created by trapped ground water becomes sufficiently great to cause a dome of frozen soil to explode. A few years ago, for example, in an area several hundred miles north of the Amur Valley, 5 adjacent domes began erupting together, hurling out great blocks of frozen soil that in some cases were as large as a small house. A Russian scientist traveling in the area reported that blocks of ejected frozen soil completely destroyed a near-by bridge as well as severely damaging the surrounding forest.

This doming tendency in regions of permafrost has caused numerous construction problems in the Soviet Union, as indeed it has in the permafrost areas of Canada and Alaska. Many domes of frozen soil seem to occur near roads. A road surface is a good radiator of earth heat. Consequently, frost is able to penetrate to a greater depth beneath the road. A veritable wall of frozen earth develops under the road. This wall acts as a dam to the circulation of ground water. Eventually the compressed water in the dome bursts through the upper frozen layers and covers the road with a flood of water which shortly turns to a glare of ice in the sub-freezing temperatures. Soviet

engineers, as well as engineers on the Alcan Highway, have found that a ditch excavated parallel to the road, but some distance from it, will give the road a considerable degree of protection. The ditch, obviously, will not retard the development of frost domes, but it does provide a run-off area for the suddenly released ground water.

Roads are not alone in the realm of permafrost construction problems. When the Trans-Siberian Railway was being laid across the permafrost area of southeastern Siberia, buildings were constructed to house workers and machinery. Heaters in the buildings kept the soil beneath the floors warm and thawing took place. Entire foundations shifted in the soggy active zone and eventually the buildings completely collapsed. In some cases, immediately beneath the stove thawing took place more rapidly than in the soil surrounding this small area. This rapid thawing provided a release for trapped ground water which would burst through the wooden floor, fill the house, and cascade through the doors and windows where it quickly froze.

In order to provide for the elimination of some of these difficulties, Russian scientists have developed a rather elaborate procedure for construction in the frontier towns that are mushrooming in the Soviet Arctic. First, an insulating layer of sawdust or moss, 2 feet thick, is laid directly on the ground. Above this layer is an air space varying in depth from 6 inches to a foot. Next is a thick wooden floor upon which is spread 6 to 8 inches of earth. Finally, the floor of the building itself is laid. The lower few feet of all outside walls are also surrounded by an additional outer wall, which encloses at least a foot of insulation.

The residents of the towns in the region of permanently frozen soil do have one noteworthy advantage. Their homes contain built-in refrigeration units. Cellars dug in the frozen soil are perfect for storing potatoes, vegetables, meat, and other perishable items. By insulating the walls of the cellar with sawdust, moss, or pine needles, a rather constant temperature slightly below freezing can be maintained.

In spite of severely adverse conditions, some agriculture is practiced in the permafrost region of the Soviet Union. This area has a number of experiment stations that are developing new seeds, as well as new methods, for carrying on agriculture in this short growing season, frozen, podzolic soil region.

The length of day in high latitude positions is partial compensation for the short duration of the period of summer warmth. The presence of the permafrost table is also an important factor in permitting plant growth. The frozen layer acts as an impervious bed which prevents the water in the active zone from escaping downward. In a region of limited precipitation, the permanently frozen layer actually offers an

advantage in that it preserves moisture in what otherwise would be extremely droughty soil.

Hardy and rapidly maturing vegetables such as cabbage, potatoes, beets, radishes, and lettuce have been raised in parts of the permafrost region for over 20 years. In the case of less hardy plants, hot houses have been constructed for their protection. A few areas have even experimented with electrically heated soil. Electrodes are placed in the ground beside the roots of the plant. This is, of course, an expensive method of carrying on agriculture. However, it should be remembered that the mining and lumber-mill towns in the permafrost region are isolated and transportation from the agricultural heart of the Soviet Union is extremely difficult. Frequently it is more expensive to transport food to these regions than it is to raise it locally despite the handicaps and costs of production.

It seems likely that as geological exploration in the permafrost region uncovers new sources of mineral wealth, as it has in the past, that the people of the Soviet Union will continue to find this a region of interest. On the other hand, it also seems likely that this is destined to remain a pioneer land. Adversity is met on every side, not the least of which is the ever-present *merzlot*, the frozen soil in the land of the Soviets.

A NEW OBSERVATORY AT WISCONSIN

Improved facilities for astronomy at the University of Wisconsin advanced another step Saturday when the Board of Regents approved final plans and specifications for a new research observatory to be located 15 miles west of Madison.

The regents also authorized advertisement for bids for the construction.

The long-needed modern building to house advanced astronomical study, together with a 53-acre site and a new telescope, is being made available through a \$200,000 gift to the University from the Wisconsin Alumni Research Foundation.

The new 'scope—a 36-inch reflecting instrument—is under construction at the firm of Boller and Schwens, S. Pasadena, Calif.

Plans and specifications call for a one-story brick building, approximately 45 by 45 feet, with concrete foundation and a basement. It will include a 25-foot steel dome, an observing floor, and small apartment quarters for a graduate student caretaker.

The new country station is to be built on land which the University purchased early this year on County Trunk T, a mile and one half northwest of Pine Bluff. On this open hill top, surrounded by low-lying woods and pastureland, the astronomers will have an unobstructed view of the skies, free of smoke and city lights problems.

The new telescope is expected to be delivered sometime late in the summer of 1957, and when in operation will provide five times the light-gathering power of the University's Washburn Observatory telescope, a 15-inch refracting instrument in use for the greater part of a century.

The country station is expected to be in operation by late 1957. WARF's gift for modernizing and expanding thus will lift Wisconsin to a point equal with other midwestern universities possessing astronomical research equipment.

PHYSICS FOR ALL

AN IMPORTANT THOUGHT FOR OUR NATION

WILLIS SWALES, JR.

Hillside High School, Hillside, New Jersey

It has long been thought that a student in high school must be above average in intelligence to take a course in Physics. It has long been a fallacy that science and mathematics courses are something to stay away from unless you intend to go on to a college or university.

This thought is far from fact. There is a great deal that every individual within our school system can gain from a course in Physics. When I say a course in Physics, I don't mean an extensive course that encompasses everything from the Pythagorean Theorem to Einstein's Theory, but those facts which everyone can and will use almost every day of his life.

It is very simple to point out facts and laws of physics that take place within every individual's daytime. The very first thing you do every morning is get out of bed. Friction makes this possible. Friction is almost always thought of as being a hindrance, but can you imagine walking on a frictionless world? Can you imagine getting out of bed and stepping onto a cake of ice? Or can you imagine trying to stop a speeding car on the same piece of ice? Friction, as a phase of physics, can be taught to all students within our school systems. Not only can it be taught, but it should be taught, to help our future citizens understand this complex world in which they live now, and are going to live as adults.

Physical science within the home is not a complicated theory. The type of heating systems for the home, insulation, the reason water runs into the house and from it, and by what type of system can be explained. If the ingredients of a cake are put into the refrigerator before mixing, they will raise much higher than by room temperature mixing. This gaseous principle is readily explained by physics.

What takes place within the electric vacuum or sweeper? I dare say that most housewives can't explain why the dirt is picked up. Or why does the washing machine, in throwing the clothes around within its interior wash and partially dry them? Centripetal and centrifugal forces need not be unknown to all of these housewives. And how do these same forces affect Dad and the car that he is driving while going around a curve at a high speed?

Electricity is a great mystery to most people. An innate fear of this great servant of man has brought forth many superstitions and fallacies that could be dispelled by a knowledge of physics. Why is a steel covered automobile a safe place to be during an electrical storm?

The simple reason is that electricity will reside on the outside of a conductor and thus leave the occupants safe and unharmed.

Now in the last paragraph I said "by a knowledge of physics." There is a great deal of difference between the definition of knowledge in this case and actually knowing the principles involved in the fact. The knowledge would be that the electricity would reside on the outside of the conductor and that you would not get out of the safe metal-encased car and run to the dangerous high tree in the area.

In setting up a non-college-prep course in physics, two things must be remembered. The first is that this course cannot, must not, be simply a general science course. It must be an actual physics course with all the facts and theories of physics—with the exception of the detailed mathematics and complicated laws. These two parts of the course must be broken down into easily understood mathematics, and very little of that, and re-written or restated principles or laws.

The biggest problem of college-prep students in physics is the mathematics involved, so it must not be expected of those with lesser abilities. The mathematics of the Metric-English equivalent is, of course, vitally necessary and should be elaborated upon. Simple density, forces, momentum, temperature conversions, electrical units, etc. are understood by most students. But they must be kept simple, or all your efforts can be enmeshed in a tangle of not-knowing and not-understanding.

In using laws and principles as they are cited from a college-prep physics text, you would tend to confuse the general physics student. To give an example, let's use Bernoulli's Effect. A college-prep text might give it in this way: "For the horizontal flow of a fluid through a tube, the sum of the pressure and kinetic energy per unit volume of the fluid is constant." A general physics text might put it this way: "Take a piece of paper and blow across the top of it. This will cause the paper to rise, indicating that the pressure on the top of the paper has been reduced. The same action takes place over a propellor-driven airplane wing. This is called Bernoulli's Effect." There isn't a law or principle that could not be broken down into language readily understood by any high school student.

It must be remembered constantly in teaching a course in general physics that there will be few "honor" students. These students will be in a class to learn "why" this is so and how it affects him in his every day life. In the classwork, if we can foster an appreciation of the scientific method, and an understanding of new scientific and sociological advances, we will be accomplishing part of our goal. Then there is certainly the necessity of dispelling "atom bomb" fears and replacing them with the realization of the good of the atom. That alone would make the course worth while.

In Hillside High School, Hillside, N. J., a course in general physics, entitled "Related Physics" is being taught. The boys taking this course are from the industrial courses. Here it is readily understood that physics is vitally important to the world's craftsmen and mechanics. Within the same school there are four classes in College Prep Physics. These four classes, plus the two in Related Physics, allow over half of the eligible juniors and seniors to become acquainted with this vital course. Of 259 people in the junior class, 164 are taking physics in some form. More high schools could do well to add similar courses. In Hillside High School, as in almost all high schools, the students in physics suffer from overcrowding due to a shortage of space and a shortage of qualified science teachers.

In our age of speed and atoms, our young people need to know more and more "why" in order to get along with understanding. There is no course in the high school today that can explain to these young people the facts of our complex age. English and history are, of course, important, but physics is vital. Administrators and school boards would be doing a real service to their community in re-evaluating their science needs and placing in their curriculum an additional course in physics for the non-college-prep students.

ETA KAPPA NU HAS FILM PROMOTING ENGINEERING CAREERS

As an aid to promoting the field of engineering as a career, Eta Kappa Nu, electrical engineering honorary, has produced a 16 mm. sound film which explains the work and opportunities available in engineering.

The film entitled, "Engineering—A Career for Tomorrow," is available in color or black and white, and can be shown in 23 to 25 minutes making it suitable for meetings or TV showings.

The recognized shortage of engineers and other trained scientific personnel will be eased, says Eta Kappa Nu, only when the high school student is shown what advantages are in store for him if he chooses an engineering career. The society believes that it is the responsibility of industry to do a more effective selling job on qualified students if it expects to develop a favorable supply of trained technical personnel.

The film, they believe, will be extremely effective in creating interest in engineering. Its best use probably will be as a basis for meetings with high school students permitting question and answer periods after the film has been shown.

Industry, it is felt, can benefit measurably by actually going out and promoting engineering careers just as they promote sales of their products. It is industry that needs the engineers, so they should take an active part in helping to develop a supply of trained technical people for the future.

Information about obtaining a print of the film may be had by writing to Mr. L. A. Spangler, Westinghouse Electric Corporation, Merchandise Mart, Chicago 54, Ill.

Humidity Detector determines moisture conditions in sealed packages without breaking the seals or packages. The electrical humidity detecting system can be used for military and industrial packs where contents must be protected from corrosion. No special training is necessary to use the device.

THE RIDDLE OF THE ICE AGES

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INTRODUCTION

50,000 years ago, give or take sundry millennia, the area now comprising the entire Northeast United States, the Great Lakes region and a major part of the Mississippi valley lay beneath a vast sheet of ice. Nearly two-thirds of the North American continent was covered by glaciers, and about half that area in Europe. The thickness of the ice ranged up to as much as 2500 ft. This was truly an era when the great white cold stalked abroad. Yet below the ice lay the remains of lush vegetation that flourished years before, depositing peat, coal and petroleum not only in what we rather myopically call the temperate zones, but even in the polar regions. In Spitzbergen, inside the Arctic Circle, where the largest tree today is a dwarf willow only three inches tall, we find fossil leaves and remains of huge trees typical of the tropics.

So we are confronted with clear evidence of a startling change in the earth's climate. To most of us, who like to think of the present climatic condition as normal, and, apart from minor variations, likely to persist for ages to come, these prehistoric phenomena are mildly disturbing. But a single swing is not the half of it. The record of the rocks shows not one but many ice ages, recurring in non-rhythmic cycles with genial interglacial periods between. And superposed on the great swings of climate, with their catastrophic effects on animal and vegetable life, we find lesser swings. There were little ice ages. There were times when the present deserts of Central Asia and the Sahara enjoyed a cool and moist climate which supported populous cities now buried in the sands.

What does it all mean? What caused the ice ages? Are they apt to recur? Here indeed is a puzzlement. Probably next in importance to the four major mysteries of space, time, life and thought, comes the riddle of the ice ages. All right, you may say, why not let bygones be bygones, why not let the dead past bury its dead? Ah, no, my friend. Here is a mystery tale de luxe, here the eternal challenge of the unsolved. Pursuit of the mystery takes us on a long journey, through hundreds of millions of years in time, and millions of miles in space. The quest brings us in contact with many branches of science. In turn we must consult the geologist, the paleontologist, the geophysicist and the geochemist, the astronomer and the astrophysicist, the meteorologist, the biologist, the volcanologist, the oceanographer, and many another.

It is not unnatural, therefore, that inquiry about the ice ages leads into other intriguing questions. When did the continents form? What makes the wind blow? What causes the ocean currents? Could volcanoes bring about glaciation? How did the ice ages affect life? Is the world getting colder or warmer? What can we learn from radio-isotope dating? Or from transatlantic radiotransmission? What causes the sun-spots? How did the ice ages affect English poetry? Why is the North Atlantic coast beset by Hazels and Carols and Dianas? Should you buy a cottage at the shore? Or an air-conditioner? The answers to these and a host of other queries are wrapped up with the mystery of the ice ages.

Now let's face it. We can't solve the ice age mystery with rigorous scientific proof. The best we can do is to adduce circumstantial evidence. Furthermore, this evidence is so detailed and so varied as to need volumes for full presentation. We must therefore content ourselves with a few essential facts and some plausible deductions. Many statements will have to be offered not only without substantiation, but without even the shreds of evidence that are available. So if anyone wishes to disagree, let him exercise that privilege.

GLACIAL EFFECTS

Let's start with a simple question: How do we know that periods of widespread glaciation ever existed? Actually this knowledge is comparatively recent. Not much more than a hundred years ago geologists were agreed that the strangely shaped and scored rocks and the abnormal, disorderly deposits found in many parts of the world resulted from a deluge that engulfed most of the continents at the time of Noah. But along about 1830 a few geologists studied the present Alpine glaciers and showed that they produce effects quite similar to those previously attributed to the Noachian flood. As more and more glacial handiwork came to light in different places, with obviously large time differences, the riddle of the ice ages took shape.

Glaciers, of course, are nothing more than snow which has been converted to ice by compaction plus internal melting and refreezing. When the ice gets thick enough, meaning some 200 feet or more, it begins to move in response to the pull of gravity. The mechanism of flow is interesting. As the pressure reaches the point where one ice grain or crystal presses too severely on another, the freezing point is momentarily lowered and a little liquid water is formed. This slips away to a place of less pressure and immediately refreezes. This process of "regelation" makes the slow motion possible. In addition, since ice is brittle, there are large-scale adjustments in the form of fissures, crevasses and the like.

As in the case of water, the rate of glacier flow depends on the

topography. Compared to a glacier, molasses in January would be a raging torrent. In a steep valley, for example, a glacier may flow from three to 50 feet a day. In other words, it advances a mile in anywhere from a fraction of a year to five years. Continental or plateau glaciers spread very slowly, maybe a mile in 25 to 50 years. So it probably takes something of the order of 25,000 years for a complete continental advance. The retreat as the glacier melts back probably occupies a like period.

As it recedes, a glacier leaves behind it a unique geomorphic aspect. The record is of two kinds, erosion and deposition. In its travel, the glacier picks up rock masses and stones and fragments quarried by the frost. These work to the bottom layer where they serve as cutting and grinding agents to produce conspicuously scratched, abraded and striated rock surfaces. Moreover, there are large-scale erosive effects. For example, valley contours and lake basins may be created through differential erosion. It is to this process that many famous lake regions can be attributed. So Wordsworth extolling the English Lake District, Virgil singing the beauty of Lake Como, and other masters of poetry, prose and paint brush owe much of their inspiration to a moving sheet of ice.

The deposits left by glaciers are as a rule less striking than the erosive effects, but may be quite impressive. Accumulated debris in the form of stones, rock fragments, sand, clay, etc., is deposited at the terminus of the glacier, forming what is known as a terminal moraine. Through a sort of ramp effect, this moraine may become much thicker than the ice that supplies it, sometimes piling up to a thickness of 200 ft. or more. In addition, as the glacier retreats, a more or less uniform sheet of debris is spread over the surface formerly covered by the ice. Such a sheet of debris as developed in continental glaciation is known as a till sheet, or sometimes merely as glacial drift. In combination, the erosive patterns, the terminal moraines and the till sheets define for us today the extent of the continental ice sheets.

THE GREAT ICE AGES

Glacial effects such as those just described are found over a large part of the earth. In North America, excluding minor swings, five glacial epochs can be recognized. At different times the ice extended as far south as Missouri, Illinois, Indiana and Ohio. In New Jersey, where this story is being written, there are glacial deposits that belong to three widely separated epochs. Moreover, the ice took up so much water from the oceans that sea level was 300 to 500 ft. below where it now is, and the shore line was a few hundred miles farther out.

In Europe six different glacial ages are distinguished. Australia had five deep freezes, South America three, and South Africa three or four. Strangest of all, some of the continental glaciers established themselves at or close to the equator—in Kenya and the Belgian Congo, for example, both of which lie directly on the equator; in Peru and Ecuador; and in Central India, well within the tropics. In South Africa the direction of flow of the ice sheets was not northward, i.e., away from the South Pole, as we might expect, but toward the pole.

When did all this happen? Well, continental glaciation is either proved or strongly suspected in all major divisions of geological time, from the Pre-Cambrian down to the Pleistocene. Tillites found in Canada and elsewhere belong to the Huronian formation, which means late Pre-Cambrian, going back maybe a billion years. The most recent glacial epochs in the Pleistocene are, of course, the best evidenced and documented. A good guess is that the four successive advances and retreats in that period occupied from a half million to a million years. The last retreat probably began some 25,000 to 50,000 years ago, or, as the geologists would say, 25,000–50,000 B. P. (*i.e.*, before the present).

CLIMATE AND LIFE

The glaciers had other consequences. Life on our planet was profoundly affected. There was, as might be expected, a terrific quantitative effect, a numerical reduction that approached or for many species reached extinction. And yet it would appear that the ice ages served a useful purpose. Had it not been for them, we should very likely not be here to discuss climatic changes. It was during the era when the great ice sheets advanced and receded several times, that extraordinary evolutionary adjustments were produced in plants and animals to enable them to survive. And it was then that the primate *Homo* emerged. If a warm lush climate had prevailed for all those millions of years, we might still be slough-wallowing amphibians.

When you come to think about it, the remarkable thing is not that there have been extremes of earth climate, but rather that the climate has for more than a billion years remained within the narrow limits essential for the origin and continuance of life. It is universally agreed that life of the kind we have on earth requires water in liquid form. This means that the temperature over a large part of the earth, as reckoned on an absolute basis, has over geologic time varied less than $\pm 15\%$.

INTERGLACIAL PERIODS

Geologically speaking, the glacial epochs were short. In between these paroxysms came much longer periods of relatively genial climate. During such warm interglacial periods the great coal beds of Great Britain and the U. S. were formed from dense tropical forests. Trees 18 inches in diameter grew in the Arctic and Antarctic. Seams of coal were laid down where now only mosses and lichens survive or where ice makes vegetation impossible.

Though some of the warm periods were moist, many were characterized by general aridity. Deserts expanded greatly, extending from sub-tropical regions into the present temperate zones. Indeed, study of desert deposits suggests that the normal geological climate is predominantly warm and dry, with conditions generally unfavorable for life.

RECENT CLIMATE

Where do we stand today? Well, our present climate seems to be about two-thirds of the way from the last glacial extreme to an interglacial extreme. According to the experts, we are still emerging from a Little Ice Age that followed the last Major Ice Age. The reality of this emergence became apparent to me during a trip to Alaska a few years ago. At Juneau the Mendenhall Glacier was receding 75 feet a year. The famed Columbia Ice Field in British Columbia was gradually disappearing. However, it would appear that the glacial retreat in the Pacific Northwest is about to be reversed for a while.

But in trying to figure out where we are, climatically speaking, we must not limit ourselves to the major swings of climate. These carry on their backs lesser swings, and these support still lesser swings, and so on until climate merges into weather. Through geological evidence, through records of growth rings on trees, through measurements of radioactive carbon 14 in plant remains and the like, we can discover all sorts of climatic cycles. Among the shorter ones we find 8,000-10,000 years, 1,000-2,000 years, a few hundred years, about 80 years, 22 years and 11 years.

EARTH MOVEMENT

Now we must get back to our major problem: what caused the ice ages? Many and complex have been the explanations advanced. Almost every conceivable causative factor, terrestrial or extra-terrestrial, has been advocated separately, and combinations of factors in almost infinite variety. In general, however, these factors can be classified in three categories: (1) variable earth movement, (2) terrestrial factors, and (3) solar activity.

First let us consider variations in the motion of the earth. Three kinds of variations enter the picture: (1) change in the shape of the earth's orbit around the sun; (2) change in the position of the equinoctial points along the earth's orbit (a phenomenon known as precession of the equinoxes); and (3) changes in the angle which the earth's axis makes with the plane of its orbit (astronomers call this a change in the obliquity of the ecliptic).

Each of these factors can produce changes in the insolational heating of the earth. (Note that the word is insolation, referring to heating by the sun.) The eccentricity of the earth's orbit varies between limits of zero and 0.07 in a period of about 100,000 years, and this changes the relative duration and intensity of winter and summer. The precession of the equinoxes, recurring in a cycle of about 25,000 years, reverses the relation of winter and summer in the two hemispheres, giving each hemisphere in turn a period of short hot summers and long cold winters. Increased obliquity gives more insolation in polar regions, and vice versa.

A one-time favorite theory says that in combination these geometric changes account for the slow climatic changes of geologic time. There are, however, seemingly insurmountable objections. Each of the changes is calculable. The magnitude of their physical effect can be estimated and is utterly inadequate to explain the major climatic swings. Also, and more important, the geometric hypothesis, taken altogether, requires that the phase of the glacial-interglacial cycle be essentially in opposition in the Northern and Southern hemispheres. The evidence runs precisely to the contrary. In general, periods of glaciation or of non-glaciation occurred simultaneously in the two hemispheres. Finally, the geometric hypothesis does not account for any of the lesser climatic cycles whose period is less than about 25,000 years. The hypothesis of pole-wandering, which has also been zealously championed, seems to be ruled out because there is nothing to connect it with the observed cyclic pattern.

ATMOSPHERIC CHANGES

Let us, then, move on quickly to terrestrial factors. Two are of principal interest: atmospheric changes and continental uplift. In the former category is a theory that an increase in the amount of carbon dioxide in the air would materially reduce the long-wave radiation of heat away from the earth without correspondingly reducing the incident short-wave heating from the sun. Thus it would act as a one-way blanket. Quantitatively this hypothesis is inadequate, and it is now pretty well rejected.

We should note, however, that water vapor acts selectively on different waves in just the same way as carbon dioxide. This is the

same sort of thing that occurs in a greenhouse, and indeed, in climatological circles the action of water vapor is known as the "greenhouse effect." So if we discover some likely cause for a substantial change in the moisture content of the air, we may have something.

The effects of volcanic dust in the air are likewise interesting. In modern times the explosions of Krakatoa (a volcano in the Malay Archipelago), Pelée (in Martinique) and Katmai (in Alaska) have thrown fine particles of dust into the air, where they remained for several years. Such volcanic dust in the stratosphere reflects and scatters the short-wave solar radiation, while permitting the long wave earth radiation to escape. Thus it tends to reduce the earth's temperature. In high latitudes, where the angle of incidence of insolation is greater, there would be more scattering. This would increase the temperature differences between polar and equatorial regions, thus producing greater air circulation and increased precipitation. This in turn could start glaciers, which once under way would by further reducing the air temperature be self-nurturing.

Another possible role of vulcanism in relation to glaciation has been suggested by V. J. Schaefer of General Electric. This expert in rain-making points out that for cloud formation and precipitation of rain or snow, we need, not only a high moisture content in the air, but numerous condensation nuclei. Volcanic ash might serve this purpose. Hence he suggests that volcanically produced condensation nuclei may have contributed to the ice ages. There seems to be nothing quantitatively unsound in this idea.

It can be said in favor of either or both of these volcanological hypotheses that evidence of volcanic activity exists for some of the glacial periods. On the other hand, some geological periods with extreme volcanicity exhibit no glaciation. At most, therefore, volcanic ash could be a necessary but by no means sufficient condition for continental glaciation.

CONTINENTAL UPLIFT

Another terrestrial factor that might operate separately or in combination with vulcanism is continental uplift. The geologists prefer the more comprehensive term "continentality." Uplift might conceivably affect climate in several ways. By blocking the circulation of atmosphere and oceans, it could cause cooling in the higher latitudes. Enlargement of the land areas in high latitudes would also produce a cooling effect. Moreover, the building up of mountains and plateaus tends to reduce the earth's temperature.

So there are those who argue that these three factors, with perhaps the assistance of volcanic ash in the atmosphere, can explain the ice ages. To account for the equatorial glaciations, they conjure

up in the Southern Hemisphere a great land mass that connected South America, Africa, India and Australia. They even give this a name, Gondwanaland. Such a barrier would direct the warm equatorial currents into the Northern Hemisphere, and the cold Southern Sea would induce heavy snow at higher elevations. Alas for such alluring conceits. There are fatal objections to the hypothesis of continental uplift as a sole cause of glacial epochs. In the record we find evidence that extensive land elevation (that is, high mountains and plateaus) was present in periods of wide glaciation but also existed in the warm interglacial periods. Most conclusive is the unmistakable geological evidence that the contours of continents and oceans existing millions of years before the Pleistocene glaciations occurred were substantially the same as they are now. So the trail narrows.

VAGUE THEORIES

We can, I think, pass over certain other implausible and far-fetched speculations. It is suggested, for instance, that the earth's axis of rotation was once shifted so as to put the South Pole at the center of the Indian Ocean. But we find no evidence of a corresponding North Pole in Texas or Mexico. Again, it is imagined that areas of nebulous matter in space might warm up the earth or cool it off. Instead of wasting time on such vague imaginings, let us move on.

SOLAR ACTIVITY

When we look outside the earth for possible causes of glaciation, it doesn't take long to hit upon the sun. That body has the commendable habit of radiating energy. The amount of energy discharged, in case any one wants to know, is about 4×10^{33} ergs per second, mostly in the form of light and heat. Of the total output, the earth receives about one two-billionth, which amounts to $1\frac{1}{2}$ horsepower per square yard. This is what, subsequent to the earth's initial cooling, has maintained its temperature within vital limits.

It is rather natural to try to explain the ice ages by a decrease in radiant solar heating, or to use our newly acquired abridgment, a decrease in insolation. The only trouble is that this theory doesn't work. Such a decrease would produce the greatest lowering of the earth's surface temperature in the tropics, and reduce the temperature difference between the poles and the tropics, rather than increase the differential to the extreme believed to have prevailed in many of the glacial periods. Moreover, the reduced temperature would cut down the water vapor content of the atmosphere, and reduce storminess and precipitation.

Well, if we can't explain glaciation by a decrease in radiant solar heating, how about an increase? This could make a little sense. The increased temperature in the warmer regions would produce greater evaporation, and likewise an increase in storminess and precipitation. The temperature near the poles might still be kept low by accumulation of winter snow, and by cloud protection against summer melting. Once started, glaciers would be self-nourishing.

Of course, if there were too much heating, all bets would be off. The ice would melt away fast and the climate would assume a torrid state for which we find no geological evidence. So this theory based on increase in direct heating, which emanates from a Britisher, one Sir George Simpson, requires rather closely controlled conditions. Furthermore, it seems likely that direct solar heating sufficiently intense to warm up the poles to produce coal would have heated the tropics far beyond the point indicated by observations. Finally, we find within historic times no evidence of change in direct solar heating sufficient to account for the observed change in climate.

We do, however, find a vast deal of evidence concerning irregular solar emission of a highly selective sort. There are wide variations in the emission of charged particles, otherwise known as corpuscular radiation, and in the radiation of ultraviolet, especially the far ultraviolet. Such changes in selective radiation are associated with sunspots, disturbances in the solar chromosphere and corona, and ionospheric and geomagnetic disturbances. Even though the energy involved in the selective radiation is relatively small, there is strong statistical evidence that connects it with recent climatic swings. And it is irregular solar radiation of this selective form, either as sole causative factor or possibly assisted by other factors such as volcanic ash, which constitutes the most plausible explanation yet advanced for the entire complex of glacial-interglacial cycles.

SUNSPOTS

Why so? First, let's talk about sunspots. A sunspot is an innocent-looking spot on the surface of the sun, consisting of an apparently dark center surrounded by a lighter border. Actually it is an eruption of incomparable violence, with a force equal to millions or even hundreds of millions of "hydrogen" bombs. The spots may be from 1,000 to 100,000 miles in diameter, the larger ones visible to the naked eye. They are magnetic, occurring in pairs, of which one is a North Pole and one a South. They often last for a month or more. Now, if the number or the area of sunspots is plotted against time, it is found that they occur in cycles, the period from one sunspot maximum to the next being about 11.1 years. Curves of this kind have

been plotted back to 1610, and maxima have been estimated as far back as AD 300, and besides the 11 year cycle we find longer and deeper ones. Of these, 78 years (*i.e.*, 7×11.1) is most pronounced.

Characteristic of sunspots are occasional brilliant eruptions, known as flares, which shoot out jets of luminous material. One of these flares emits all sorts of radiation: streams of corpuscles, intense ultraviolet, and radio waves over a wide frequency band. The effects experienced on the earth are well known. Where the corpuscles are drawn toward the poles there is a brilliant aurora. Magnetic storms knock out teletype, power lines, and short-wave radio.

Further, and most surprising, we have incontrovertible evidence, accumulated over the past two centuries, that shorter range changes of climate correlate closely with changes in sunspot activity. While there is definite correlation in the 11 and 22 year cycles, the most striking parallelism is found in the more extreme 78 (or roughly 80) year cycles. The 40 year period following the highest sunspot maximum is characterized by a cool, wet climate, while the 40 year return from the lowest maximum corresponds to warm and dry.

We find other correlations, too. The change in the 80 year sunspot cycle is accompanied by a change in air circulation. Following the max-max there is a regular pattern of wind zones which gives a steady progression of moisture-bearing storms. In the other half of the cycle there are more irregular wind patterns which on the average yield a warmer and drier climate.

How on earth can our weather be influenced by spots on the sun? We just don't know. All theory as to the mechanism of interrelation is highly conjectural. Ultraviolet radiation seems to predominate during the cold, wet periods, and corpuscular at times of warm and dry. The principal effect of ultraviolet radiation is thought to be electrochemical, resulting in an increase of ozone which by virtue of the greenhouse effect would reduce temperature gradients and set up zonal air circulation. The corpuscular bombardment, being focussed toward the poles by the earth's magnetic field, is presumed to heat the polar regions through absorption of the kinetic energy of the particles in the upper atmosphere. No one has yet discovered how to measure such effects. Whenever we succeed in placing a satellite above the earth's atmosphere, this will make it possible to monitor the electromagnetic radiation arriving from the sun, and this may yield a better understanding of what happens.

So, if sunspots cause changes in climate, what causes the sunspots? That is another mystery, best reserved for separate attention. The fact is that nobody knows for sure, and the best theories require, for complete comprehension, a good grounding in modern physics.

We now come back to the ice ages. No one can say whether these

extreme climatic derangements resulted from ultra-intense solar activity of the type which seems clearly responsible for the lesser climatic swings. The best we can do is to find some good arguments for such a hypothesis. First, in default of evidence to the contrary, it seems logical to attribute all climatic cycles to the same cause. Second, the effects of selective solar emissions would be roughly in phase in the two hemispheres, as is the case for the best documented glaciations. Third, such emissions produce air circulation patterns of the kind that seems essential. Fourth, we can find no other satisfactory explanation. So when all is said, we find no definitive, categorical answer to our riddle.

FUTURE CLIMATE

Some day, however, maybe 50,000 years from now, man, if he has not succeeded in self-annihilation by nuclear bombs, will learn the answer. For, if the past is any index of the future, there will be another period of mighty solar ebullition. Gradually the glaciers will return to New Jersey and Ohio and Missouri. And lacking sufficient fuel to melt away the ice sheets, man will huddle around the earth's middle belt, or embark on space ships in search of a more salubrious climate.

Be that as may, the near-range future holds more of interest. Using sunspot and weather data of the sort mentioned above, Dr. Hurd C. Willett, Professor of Meteorology at M.I.T., presents, in a recent issue of the *Saturday Evening Post*, some significant weather predictions for the next 40 years or so. We are just entering, he says, a period of moister and colder weather, which will bring lots of snow and ice. Tropical hurricanes will no longer roar up the Atlantic seaboard; they will stay where they belong. Inland lakes will fill up, and the ocean will recede. By 1965 or 1970 New York harbor may freeze solid in the wintertime. So it might be well to sink some money in a snowshovel and a heavy winter overcoat.

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FIRST AID FOR THE UPPER ELEMENTARY AND GENERAL SCIENCE CLASSES

HAROLD HAINFELD

Roosevelt School, Union City, N. J.

Accidents to school age children are the concern of parents, science teachers and school administrators. They are a major cause of school absences and fatalities in the 8-16 year age bracket. Every effort should be made to make the youngsters aware of the seriousness of their accident problem.

Most science texts for the upper elementary and general science courses contain material about human conservation or health education. Science teachers have a certain responsibility in their instruction about safety and health of their students.

One way of presenting this information is to include material on first aid as part of this instruction. One of the objects of a course of this type is to make the students conscious of the accident and safety problem. With proper training, a safer attitude can develop as information and skills are learned about caring for those injured in accidents.

First Aid can be taught to students as part of their junior high school science program or in the upper elementary grades or in the general science course. The Junior Red Cross First Aid course is designed to start in the seventh grade for boys and girls over 12 years old. It can well fit into three weeks of instruction or be part of the science club activities. At Roosevelt School, Union City, N. J., the 8th grade class receives this instruction as part of their science instruction. About 500 certificates have been issued to our students by the North Hudson Chapter of the Red Cross during the past ten years.

The instruction is valuable in making the students safety conscious about the accident problem and their own safety. As part of their course, students learn about the latest Nielsen "back-pressure-arm lift" method of artificial respiration. Also, the pressure points, essential to the stopping of arterial bleeding, the treatment for shock and poisons. These are life saving actions, where quick action is necessary to prevent a victim of an accident from becoming a fatality.

As first aid is the immediate and temporary care given to the victim of an accident or sudden illness, other skills and information are taught as part of the course. Students learn to apply bandages and dressings, apply splints, study about fractures, burns, and wounds and what to do in each case. They also study about transportation for the injured and about first aid for some emergencies that can

arise in the home or at play as poison ivy and oak, blisters, frostbite, sunstroke and how to take a persons temperature and pulse.

The course has added values in that first aid information is brought home to the parents. Pamphlets prepared by the Metropolitan Life Insurance Company and Johnson and Johnson are distributed to the students for their use and to take home. Copies of *First Aid* can be obtained from your local Metropolitan Agency or by writing to the School Service Department, Metropolitan Life Insurance Company, 1 Madison Avenue, New York City, N. Y.

Help Wanted prepared by Johnson & Johnson, New Brunswick, N. J. contains valuable information plus suggestions for home and automobile first aid kits and supplies. Their 16 mm. sound motion picture by the same title was recently revised to include information about the Nielsen "back pressure-arm lift" method of artificial respiration. Film can be obtained from Johnson & Johnson for return postage. The pamphlets for the class are sent with the film.

Another 16 mm. sound moving picture is "Danger Is Your Companion," which can be obtained from your local Red Cross Chapter. This film makes an excellent introduction to the unit as it shows the importance of first aid training and emphasizes that you may never have to use the skills and information, but then, you may be the only person at the scene of an accident and save a life with your knowledge.

"Non-Combat First Aid," prepared by the Army Signal Corps, is filmed with typical military realism. It is well worth the "red tape" to get this film for your class. Write to the Army Signal Officer, Film Division in the Army Headquarters in your area for the necessary requisition forms.

Coronet and Encyclopaedia Britannica Films both have produced fine films on this subject. There is plenty of good audio-visual materials available to help in the first aid instruction for your students. Your local Red Cross chapter can help with a booklet outlining the junior course. Lesson plans and other suggestions are included in it. The 15 hour junior course fits well into three weeks of science instruction or into a half years science club meeting program.

Science teachers can easily qualify for the instructors rating. In many cases they have had the Standard and Advanced first aid course as part of their undergraduate course. This 20 hour course plus a three hour instructors course qualifies a person for the instructors rating. While this rating is not necessary to give the instruction, certificates can only be issued by the instructors. These have proven valuable as the science teacher has helped to qualify Girl and Boy Scouts for the requirements for the First Aid Merit Badge.

With a growing emphasis on Civil Defense, First Aid can be a valuable part of the science course. Science teachers are being asked

to assist in phases of Civil Defense. Instructing in First Aid procedures at the upper elementary or in the general science class can be valuable in developing safer attitudes, provide valuable skills for an emergency and bring valuable and useful information to the home.

SUGGESTED REWORDING OF PROPOSED CHANGES IN ARTICLE III OF THE CONSTITUTION OF CASMT

Following the instructions of the 1955 convention the Constitution Revisions Committee, under the chairmanship of Mr. Wren, presented to the Board of Directors of CASMT during its 1956 Convention a rewording of proposed changes in Article III, Sections I, II, and III c, f, g. The "rewording" was approved by the Board as submitted with the recommendations that arrangements be made to publish the approved rewording in two successive issues of the *Journal* during 1957 in order that the proposed change may be acted upon at a general meeting of the 1957 convention.

The suggested rewording is given below together with the portion of the constitution and by-laws affected by the change. The change clarifies the use of the term "Secretary and Historian" as indicating a single office and makes it possible to use the term "Assistant Secretary" without danger of confusion as to duties.

The proposed changes are italicized.

PROPOSED ARTICLE III, SECTION I, OFFICERS:

The officers of this Association shall be a President, a Vice-President, a *Secretary and Historian*, a Treasurer and Business Manager, an Editor of the *Journal*. *One or more Assistant Secretaries, Assistant Editors, and Assistant Treasurers may be appointed by the Board of Directors.*

The officers of this Association shall be a President, a Vice-President, a Secretary, a Treasurer and Business Manager, an Editor of the *Journal* and an Historian. One or more Assistant Secretaries and Treasurers may be appointed by the President.

PROPOSED ARTICLE III—SECTION III, ELECTION, TENURE OF OFFICE, COMPENSATION:

The President and Vice-President shall be elected by the members of the Association at the annual meeting and shall serve for a term of one year or until their successors are elected. *The Treasurer and Business Manager, Editor of the Journal, Secretary and Historian shall be appointed for a term of three years by the Board of Directors at a meeting to be held following the annual meeting of the Association, or at the Spring meeting of the Board of Directors. The Secretary and Historian shall take office immediately following appointment. The Treasurer and Business Manager, and Editor of the Journal shall take office at the beginning of the fiscal year following their appointment. They may be reappointed.* The compensation of the officers, if any, shall be fixed by the Board of Directors.

The Treasurer and Business Manager, Editor of the *Journal*, Historian, and Secretary shall be appointed by the Board of Directors at a meeting to be held following the annual meeting of the Association, and shall serve for a term of three years. Their terms may be renewable.

The above changes would call for the combining into one item the two items (c) and (f) of Article III, Section IV. Item (g) of this section would then become item (f) and there would be no item (g).

PROPOSED CHANGES IN ARTICLE III, SECTION IV, (C) SECRETARY AND HISTORIAN:

The Secretary and Historian shall keep all records and minutes of all meetings; shall prepare and submit a complete report of the Annual meeting to the Editors of the Journal by December 31st following the meeting; and shall be charged with the responsibility of collecting and preserving the historical documents of the Association.

(C) SECRETARY: The Secretary shall keep all records, minutes of all meetings, and shall prepare and submit a complete report of the annual meeting to the Editor of the Journal by December 31st following the meeting.

(F) HISTORIAN: The Historian shall be charged with the responsibility of collecting and preserving historical documents of the Association.

SCIENCE AND MATHEMATICS AT STANFORD

The National Science Foundation has granted \$280,000 to Stanford University to conduct an institute during the 1957-58 academic year for high school teachers of science and mathematics, President Wallace Sterling announced today.

Fifty participants will be selected from men and women teachers in high schools of the United States and its territories. Each award will include full tuition of \$750, \$3,000 in stipend, allowance of \$30 a month for each dependent up to four, \$50 for books, and travel costs.

Harold M. Bacon, professor of mathematics, has been appointed institute director and Paul DeH. Hurd, associate professor of education, is associate director.

Participants will choose their programs from the full range of the University's curriculum, primarily in the sciences, mathematics, and education. Additional special courses will be provided.

The Foundation has made grants totaling \$4,065,000 to 16 colleges and universities for similar year-long institutes, according to Alan T. Waterman, NSF director.

The program is intended to keep the high school teachers abreast of developments in their fields and to help increase the supply of top quality scientists and engineers, Dr. Waterman said.

Applicants for the Stanford Institute must have a bachelor's degree, at least three years' teaching experience, and expect to remain in the profession. Applications should be postmarked on or before February 21.

Requests for information and application forms may be addressed to NSF Institute, Room 70, Mathematics Building, Stanford University, Stanford, California.

Transistorized PA System is built into an attache case. Weighing 18 pounds, the portable public address system can be carried like luggage and is powered by two flashlight batteries. It consists of a Hi-Fi transistor amplifier, a heavy-duty eight-inch speaker, a microphone and controls.

Washable Paint covers an unpainted area with one coat. Based on a plastic vinyl acetate resin latex, the interior paints may be compounded at a pigment volume greater than that for latex paints. The paint provides one-coat hiding with no sacrifice in washability and freeze-thaw stability.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution as on the following pages.

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.
2. Drawings in India ink should be on a separate page from the solution.
3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2534, 2437. *J. Byers King, Denton, Md.*

2539. *Proposed by Vincent C. Harris, San Diego State College.*

Which requires less material (that is, has less surface area), a cylinder of the most economical proportions or a cube, if they contain the same volume.

Solution by Cecil B. Read, University of Wichita, Wichita, Kan.

The problem as stated is ambiguous—does the container have a lid or not?

By the classic "tomato can" problems of elementary calculus, a closed cylinder has the least surface area if diameter equals height; one without a top (a cup) has the least surface area if radius equals height.

For the first case, for unit volume,

$$d=h=\sqrt[3]{4/\pi}$$

while surface area is $3\pi d^2/2$ or approximately 5.54 square units, less than for a cube, with 6 square units.

For the second case, for unit volume,

$$r=h=\sqrt[3]{1/\pi};$$

surface area = $3\pi r^2$ or approximately 4.39 square units, the open top cube would use 5 square units.

Hence in both cases, the cylinder will use the least material.

Solutions were also offered by V. C. Bailey, Evansville, Ind.; Julian H. Braun, San Diego, Calif.; A. R. Haynes, Tacoma, Wash.; Sister Mary Leona, Saginaw, Mich.; R. L. Moenter, Fremont, Mich.; Willis B. Porter, New Iberia, La.; W. R. Talbot, Jefferson City, Mo.; and the proposer.

2540. *Proposed by James Dowdy, San Antonio, Texas.*

Prove that

$$\pi = 2i \log \frac{1-i}{1+i},$$

where

$$i = \sqrt{-1}.$$

Solution by C. N. Mills, Florida State University

We know that

$$e^{ix} = \cos x + i \sin x.$$

When $x = \pi$, then

$$e^{i\pi} = -1.$$

Extracting the square root of each member of the preceding equation, gives

$$e^{i\pi/2} = i.$$

The following identity holds,

$$\frac{(1+i)^2}{2} = i.$$

Since

$$\frac{(1+i)^2}{2} = \frac{1+i}{2/(1+i)} = \frac{1+i}{1-i},$$

we have

$$e^{i\pi/2} = \frac{1+i}{1-i}.$$

Taking the logarithm of each member of the preceding equation, then multiplying each member of the resulting equation by $2i$, and simplifying, the required relationship is obtained.

Solutions were also offered by V. C. Bailey, Evansville, Ind.; Julian H. Braun, San Diego, Calif.; Cy Cantrell, Ithaca, N. Y.; Charles A. Field, Hartford, Conn.; A. R. Haynes, Tacoma, Wash.; Jerry King, Lexington, Ky.; R. L. Moenter, Fremont, Neb.; Willis B. Porter, New Iberia, La.; W. R. Talbot, Jefferson City, Mo.; and the proposer.

2541. *Submitted by Brother Felix John, Phila., Pa.*

Is the following expression an identity or an equation? Prove or solve, if possible.

$$\frac{\sin X + \sin 2X}{\sin X + \sin 3X} = \frac{\sin 3X(1 - \tan^2 X)}{\sin 4X(2 \cos X - 1)}.$$

Solution by the proposer

1. Suppose it is an identity. Operate first on the righthand member:

$$\frac{\sin X(3 - 4 \sin^2 X)(1 - \tan^2 X)}{4 \sin X \cos X(\cos^2 X - \sin^2 X)(2 \cos X - 1)}.$$

2. But

$$(3 - 4 \sin^2 X) = (4 \cos^2 X - 1),$$

and

$$1 - \tan^2 X = \frac{\cos^2 X - \sin^2 X}{\cos^2 X}.$$

3. Substituting these values in the first step, and simplifying:

$$\frac{2 \cos X + 1}{4 \cos^3 X}$$

4. Simplifying the lefthand member gives

$$\frac{\sin X(1+2 \cos X)}{\sin X(4-4 \sin^2 X)}$$

5. But the expression in parentheses in the denominator $= 4 \cos^2 X$. Therefore, the left-hand member reduces to

$$\frac{2 \cos X + 1}{4 \cos^2 X}$$

6. Since 3. and 5. are not the same, the expression is not an identity.

7. If it is an equation, then

$$4 \cos^2 X (\cos X - 1) (2 \cos X + 1) = 0.$$

8. Using principal values only, $X = 0^\circ, 90^\circ, 120^\circ, 240^\circ$, and 270° .

9. Of these 5 possible solutions, only 120° and 240° check. 0° yields $0/0 = 0/0$; 90° and 270° give either $1/-1$ or $-1/1 = (0x - \text{inf.})/(0x - 1)$.

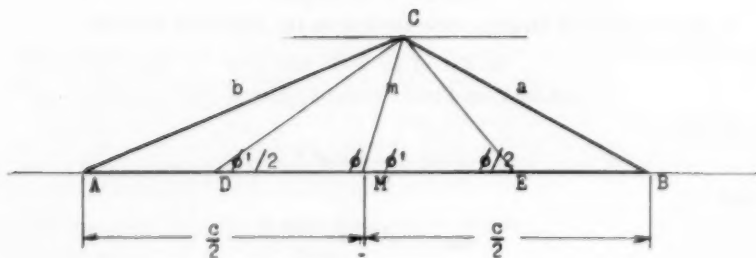
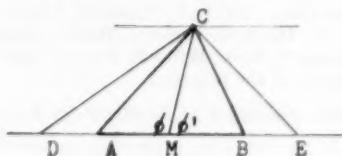
Solutions were also offered by Donald Barnhouse, Wheeling, W. Va.; Julian H. Braun, San Diego, Calif.; A. R. Haynes, Tacoma, Wash.; Sister Mary Leona, Saginaw, Mich.; Sister Marcia, Roseto, Pa.; George E. McFadden, Buffalo, N. Y.; and Walter R. Warne, St. Petersburg, Fla.

2542. Proposed by Nathan Altshiller-Court, University of Oklahoma.

Find the length (in terms of the sides) of the segment determined on a side of a triangle by the bisectors of the angles formed by the median relative to that side and the parallel to that side through the opposite vertex.

Solution by Sister Mary Leona, Saginaw, Mich.

Let ϕ and ϕ' be the angles made by the median CM and the side AB of the



triangle ABC . Then the bisectors of the angles formed by the median and the line through C parallel to AB gives

$$\angle MDC = \angle DCM = \phi'/2$$

and

$$\angle MEC = \angle ECM = \phi/2,$$

where

$$\phi/2 + \phi'/2 = \pi/2.$$

The $\triangle DMC$ and $\triangle CME$ are therefore isosceles with $DM = MC = ME$.

Designating the sides of the triangle by a , b , and c ; the difference $AB - DE$ by $2d$ or $AM - DM = d$; and the median by m , $m = c/2 - d$,

$$b^2 = (c/2)^2 + m^2 - cm \cos \phi$$

or

$$(1) \quad b^2 = (c/2)^2 + (c/2 - d)^2 - c(c/2 - d) \cos \phi$$

$$a^2 = (c/2)^2 + (c/2 - d)^2 - c(c/2 - d) \cos \phi'$$

or

$$(2) \quad a^2 = (c/2)^2 + (c/2 - d)^2 + c(c/2 - d) \cos \phi.$$

Adding equations (1) and (2)

$$a^2 + b^2 = c^2/2 + 2(c/2 - d)^2.$$

Solving for d

$$d = c/2 - \frac{\sqrt{2a^2 + 2b^2 - c^2}}{2}.$$

The required distance is then

$$DE = 2DM = 2(c/2 - d) = \sqrt{2a^2 + 2b^2 - c^2}.$$

Solutions were also offered by V. C. Bailey, Evansville, Ind.; W. R. Talbot, Jefferson City, Mo.; and the proposer.

2543. *Proposed by Hugo Brandt, Chicago, Ill.*

Prove

$$|a_1 \ b_2 \ c_3|^2 = |A_1 \ B_2 \ C_3|$$

where

$$|a_1 \ b_2 \ c_3|$$

stands for

$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

and A_1 , etc. is the minor of a_1 , etc., or

$$A_1 = \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix}.$$

Solution by W. R. Talbot, Jefferson City, Miss.

Let

$$|a_1 \ b_1 \ c_1| = D.$$

Consider the product

$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} \cdot \begin{vmatrix} A_1 & -A_2 & A_3 \\ -B_1 & -B_2 & -B_3 \\ C_1 & C_2 & C_3 \end{vmatrix}.$$

The elements of the product

$$a_i A_j - b_i B_j + c_i C_j$$

will be $+D$ or $-D$ if $i=j$, and will be 0 if $i \neq j$. When $i \neq j$ the element is equivalent to the expansion of a determinant with two rows the same. The product determinant becomes

$$\begin{vmatrix} D & 0 & 0 \\ 0 & -D & 0 \\ 0 & 0 & -D \end{vmatrix} = -D^3.$$

Then the second member of the product above must equal $-D^3$. Removal of the -1 factor and interchanging rows and columns will show that

$$|A_1 \ B_2 \ C_3| = |a_1 \ b_2 \ c_3|^2.$$

Solutions were also offered by A. R. Haynes, Tacoma, Wash.; and the proposer.

2544. Proposed by Julius Sumner Miller, El Camino College, Calif.

A rough sphere of radius r rolls inside of a fixed hollow sphere of radius $4r$. Find the least velocity in its lowest position so that it may retain contact with the highest point of the hollow sphere.

Solution by the Proposer

By energy considerations,

$$KE_B = KE_T + PE_T,$$

where the subscripts B and T mean *bottom* and *top* respectively. Then

$$\begin{aligned} \frac{1}{2} m V_B^2 + \frac{1}{2} I \omega_B^2 &= \frac{1}{2} m V_T^2 + \frac{1}{2} I \omega_T^2 + mgh \\ \frac{1}{2} m V_B^2 + \frac{1}{2} \cdot \frac{2}{5} m r^2 \frac{V_B^2}{r^2} &= \frac{1}{2} m \cdot 3gr + \frac{1}{2} \cdot \frac{2}{5} m r^2 \cdot \frac{3gr}{r^2} + mg \cdot 6r \\ \frac{7}{10} V_B^2 &= \frac{3}{2} gr + \frac{3}{5} gr + 6gr. \end{aligned}$$

Whence

$$V_B^2 = \frac{81}{7} gr.$$

Note:

(1) We utilize

$$V = \omega r$$

(2)

$$\frac{m V^2}{R} = mg \quad \text{whence} \quad V = \sqrt{gR} = \sqrt{g \cdot 3r}$$

(3)

$$h = 6r.$$

Show that for the small sphere to have no velocity at the top

$$V_B^2 = \frac{60}{7} gr.$$

A solution was also offered by V. C. Bailey, Evansville, Ind.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2563. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kan.*

A problem frequently found in algebra books a generation ago was: At what time after a specified hour will the hour hand and the minute hand of a clock be together? The modern electric clock often has an hour, a minute, and a second hand; at what time after 12 o'clock will the three hands again be together?

2564. *Proposed by A. R. Haynes, Tacoma, Wash.*

1. Show that the locus of the intersections of the normals at the ends of a system of parallel chords of the parabola $y^2 = 4ax$ is a straight line.

2. Find the relationship which exists between the slope of the locus and the slope of the parallel chords.

3. a) When the angle which the locus makes with the x -axis is $3\pi/4$, find the angle which the parallel chords make with the x -axis.

b) When the angle which the parallel chords make with the x -axis is $2\pi/3$, find the angle which the locus makes with the x -axis.

2565. *Proposed by Julius Sumner Miller, El Camino College, El Camino, Calif.*

A particle attached to a fixed point by a string of length L which is taut and horizontal is released and the string, when passing through the vertical, catches a peg at depth d below the fixed point. Find d below the fixed point. Find d if the particle then just makes a complete revolution.

2566. *Proposed by Cecil B. Read, Wichita, Kan.*

A knight and a pawn are placed at random on a chess board; if it is the knight's move what is the chance that it can take the pawn with that move?

2567. *Proposed by Brother Felix John, Philadelphia, Pa.*

Show that

$$\ln \frac{(1+x)^{1/(1-x)}}{(1-x)^{1/(1+x)}} = x + \frac{5x^3}{2x^3+9x^5} + \frac{4x^5+13x^7}{6x^7+\dots}$$

2568. *Proposed by A. R. Haynes, Tacoma, Wash.*

An island PQ , one mile wide, lies in a direct line between two cities, A and B , on opposite shores of the river. From O , a point up the river, the channels AP and BQ subtend angles of $45^\circ 35'$ and $25^\circ 10'$ respectively, while the island subtends an angle of $8^\circ 28'$. The cities are known to be 11 miles apart. Find the widths of the channels, the channel adjacent to A being observed to be the greater.

BOOKS AND PAMPHLETS RECEIVED

ELEMENTS OF MATHEMATICS, Second Edition, by Helen Murry, *University of Connecticut*, and Doris Skillman Stockton, *University of Massachusetts*. Cloth. Pages x+308. 17×25.5 cm. 1956. Addison-Wesley Publishing Company, Inc., Reading, Mass. Price \$3.50.

AN ENCYCLOPAEDIA OF THE IRON AND STEEL INDUSTRY, Compiled by A. K. Osborne, A. Met., *Technical Librarian and Information Officer, The Brown-Firth Research Laboratories, Sheffield*. Cloth. Pages xi+558. 14.5×24 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price \$25.00.

ELEMENTS OF ALGEBRA, by Howard Levi, *Professor of Mathematics, School of General Studies, Columbia University*. Second Edition. Cloth. Pages viii+160. 13×20.5 cm. 1956. Chelsea Publishing Company, 552 W. 181 Street, New York 33, N. Y. Price \$3.25.

SMALL-SCALE QUALITATIVE ANALYSIS FOR SCHOOLS, A.R.C.Sc., B.Sc., *Senior Chemistry Master, Borden Grammar School, Sittingbourne*. Cloth. Pages x+70. 12×18.5 cm. 1956. John Murray, Publishers, Ltd., 50 Albemarle Street, London, W. 1. England. Price 6s.6d.

ANIMALS IN SCHOOLS, by J. P. Volrath. Cloth. 144 pages. 12×18.5 cm. 1956. John Murray, Publishers, Ltd., 50 Albemarle Street, London, W. 1. England. Price 12s. 6d. net.

INTERMEDIATE ALGEBRA, by Paul K. Rees, *Professor of Mathematics, Louisiana State University*, and Fred W. Sparks, *Professor of Mathematics, Texas Technological College*. Second Edition. Cloth. Pages x+306. 14.5×23 cm. 1957. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price \$3.90.

ALPHABETICS AS A SCIENCE, by Walter C. Durfee. Cloth. Pages x+45. 13.5×21.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price \$4.75.

MATHEMATICS MAGIC AND MYSTERY, by Martin Gardner. Paper. Pages xii+176. 13×20 cm. 1956. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price \$1.00.

CALCULUS REFRESHER FOR TECHNICAL MEN, by A. Albert Klaf, B.S., M.E., *Civil Engineer, Board of Water Supply, City of New York*. Paper. Pages viii+431. 13.5×20.5 cm. 1956. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price \$1.95.

TRIGONOMETRY REFRESHER FOR TECHNICAL MEN, by A. Albert Klaf, B.S., M.E., *Civil Engineer, Board of Water Supply, City of New York*. Paper. Pages x+269. 13.5×20.5 cm. 1956. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price \$1.95.

DESCRIPTIVE GEOMETRY, by Steve M. Slaby, *Assistant Professor of Graphics, School of Engineering, Princeton University*. Paper. Pages xiii+353. 13×21 cm. 1956. Barnes and Noble, Inc., 105 Fifth Avenue, New York 3, N. Y. Price \$2.25

THE LEIBNIZ-CLARKE CORRESPONDENCE, by H. G. Alexander, *Lecturer in Philosophy in the University of Manchester*. Cloth. Pages lvi+200. 12×18.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price \$4.75.

THE NEED FOR HIGH SCHOOL PHYSICS IN AN INDUSTRIAL COMMUNITY. Proceedings of the Pittsburgh Conference, by Editor W. C. Kelly, *Associate Professor of Physics, University of Pittsburgh*. Paper. Pages vii+30. 21×28.5 cm. 1956. University of Pittsburgh Press, Pittsburgh 13, Pa. Price 50 cents per copy.

BOOK REVIEWS

CHEMISTRY MAGIC, by Kenneth M. Swezey. Cloth. Pages x+180. 15×23 cm. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price \$4.50.

This book is just what the amateur chemist has been seeking. So often a child, without proper guidance and instruction, plays with his chemistry set just to see what will happen when he mixes two substances. Frequently serious accidents occur and no chemistry is learned. But this author begins his book with several pages on "The Chemist's Workshop," where he describes all the simple apparatus and utensils used, giving pictures of operations, tools and equipment, and telling how to use them. The student should refer to these pages frequently because he will forget. The pages on "Basic Laboratory Technique" show him the necessity for cleanliness, telling him how to clean his apparatus and dispose of the waste chemicals left over. Many general rules for successfully performing his experiments are given. He is then ready to try some simple but very interesting experiments. He is not just told what to do, as in many classroom manuals, but each process is discussed so that he knows all about the reactions and his finished product and its uses. About 200 interesting demonstrations and experiments are so presented, arranged in related groups. In the latter part of the book, which requires some additional apparatus, are some very interesting experiments on recent developments such as some of the new improvements in refrigeration, uranium, x-rays, ultraviolet light, colloids, emulsions, invisible light, and color analysis. Anyone who carries through the experiments of this book will have acquired a lot of chemistry knowledge and will have had fun all the time. The many photographs of the apparatus used, with their instructive captions, tell much in few words but with elaborate clarity.

The author has had years of experience in teaching and in writing for the amateur. As a popular lecturer, a contributor to *Popular Science* for many years, and as an author of such other books as *After-dinner Science* and *Science Magic*, he is unexcelled.

G. W. W.

AN ENCYCLOPAEDIA OF THE IRON AND STEEL INDUSTRY, compiled by A. K. Osborne, A. Met., *Technical Librarian and Information Officer, The Brown-Firth Research Laboratories, Sheffield*. Cloth. Pages xi+558. 14.5×24 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price \$25.00.

No better description of this book can be given than the following sentences from the Preface: "The purpose of this *Encyclopaedia* is to provide a concise description of the materials, plant, tools and processes used in the Iron and Steel Industry, and in those industries closely allied to it, from the preparation of the ore down to the finished product; and to define the technical terms employed. The work is intended as a work of reference, not in any sense as a textbook."

The *Encyclopaedia* is made up of 470 pages of descriptive and explanatory matter, which covers the entire industry, plus Frontispiece in color and sixteen full page photographs illustrating some of the gigantic pieces of apparatus and important processes. Nine diagrams also help to explain some sections difficult to make clear by words alone. Preceding the *Encyclopaedia* are instructive diagrams of iron and steel production. Following the *Encyclopaedia* is a section consisting of one page describing the "Oberhausen Processes" and six pages of new material collected after the other manuscript was closed for the press. The References cover twenty-eight pages. Five Appendices give conversion tables, weights and measures, properties, signs and symbols, and scientific, technical and trade societies and other bodies related to the iron and steel industries. Here we see some of the difficulties encountered by use of two thermometric scales and two systems of weights and measures, much of which could be entirely

eliminated if the Iron and Steel Industries of England and the United States should discard the old difficult English system and adopt the metric system along with the rest of the world.

Now let us look at a page or two of the text. The terms discussed consist of such words as hydrometer and hysteresis, or abbreviations as I.E.E. and I.G., or phrases as hypersonic analyzer and Igewsky's reagent. Many of the discussions or definitions are followed by a letter and number in parentheses as (H. 13.) which give in the set of References the source of the information. Page 170, e.g., may be perfectly clear to the reader until he reaches the expression *foundry returns*, where he encounters "metal in the form of gates, sprues, runners, risers," etc. These terms are all cleared up by referring to the words in their alphabetical places in the *Encyclopaedia*. Again under *fountain* is found "an alternative name for the *trumpet* used in *uphill casting*." Again all the reader needs to do, if this short sentence needs explanation, is to look up the italicized terms which are given in the proper lists of the *Encyclopaedia*. Twenty-five dollars looks like a big price for one volume, but those with particular interests in iron and steel will find it very cheap in the time saved and the satisfaction given.

G. W. W.

BETWEEN THE PLANETS, by Fletcher G. Watson, *Associate Professor of Education at Harvard*. Revised Edition. Cloth. Pages vi+188+40. 15×23.5 cm. 1956. Harvard University Press, Cambridge, Mass. Price \$5.00.

All who are acquainted with *The Harvard Books on Astronomy* will be glad to see this revision of *Between the Planets*. Much has been found out about the solar system since 1941, when this set first appeared. The new telescopes and the many refinements and improvements on other related instruments have given astronomers new views of the heavenly bodies and enabled them to see and measure many new ones. This book is one of the series that all can read and enjoy. It is mostly descriptive and explanatory, contains little mathematics, and uses few symbols. The measurements are mostly given in metric units. The text has been almost completely rewritten and new material included throughout. New data have been added to the tables showing the measurements and discoveries in recent years, bringing the book right up to the present time. The plates have been collected in one section following the text thus keeping the price relatively low. One entirely new chapter, "Radio Writes a Record," has been added, as well as much new material in all other chapters. Few errors in type were noted, showing that the proof has been well read and corrected. You will want this new edition to keep your library up to date. It should be in every high school library.

G. W. W.

THE SCRIBNER ARITHMETIC BOOKS, 3, 4, 5 AND 6, by Richard Madden, William A. Gager, and Leslie S. Beatty. Book 3, 328 pages. Book 4, 327 pages. Book 5, 327 pages. Book 6, 343 pages. Book 7, by William A. Gager, Beulah Echols, Carl N. Shuster, Richard Madden, and Franklin W. Kokomoor. Pages viii+390. Book 8, by William A. Gager, Dorris H. Johnson, Carl N. Shuster, Richard Madden, and Franklin W. Kokomoor. Pages viii+373. Each Cloth. 15×21.5 cm. 1955. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Books 3, 4, 5, 6 are \$2.12. Books 7 and 8 are \$2.24.

This set of books for pupils from grade three through grade eight certainly makes arithmetic a fascinating subject. Teachers should compare the books used today with those used fifty years ago to realize the progress of the subject. Here the children start with a story, beautifully illustrated in color and about things they contact daily. Their interest is already present. First they are counting but they scarcely realize that any change has been made as they proceed to addition and subtraction. Multiplying and dividing likewise follow without noticeable change. The teacher should start at the close of the book, going over carefully the last two pages in preliminary study. In the second book she will find the following excellent paragraph, which is the key to all the work of the text:

"The classroom should be a learning laboratory containing many materials for measuring, counting, visualizing processes, and developing mathematical ideas. There should be blocks, containers, scales, clocks, thermometers, rulers, yardsticks, steel tapes, calendars, charts of processes, and many other materials for use in the classroom laboratory."

Before the child is through Book 4 he has learned how to measure many things and to make computations in denominate numbers and measurement. In Book 6 he becomes acquainted with the metric system by assuming travels to Mexico, and has learned many of the elements of bookkeeping and accounts. Books 7 and 8, by a new set of authors except one, carry out the same principles as before but take the students into more advanced topics which require additional care and systematic reasoning. By carrying out the thought and the new processes involved every pupil should be able to take up high school work that follows without great effort.

If you look over this set of arithmetics before you choose you will be well repaid.

G. W. W.

FUN WITH FIGURES, by J. A. H. Hunter. Cloth. Pages xi+160. 12×19 cm. 1956. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price \$3.00.

This little book will produce just what the title says. It is a book for one to enjoy while alone or for bringing pleasure and recreation to a group. It will furnish hours of entertainment for all who are a bit mathematically minded whether college trained or with only grade school arithmetic. Some of the puzzles are most easily solved by applying a little high school mathematics but correct answers may be obtained by just a little careful thought. Some typical solutions are provided in the back of the book and a list of answers. But not all answers are given because some of the problems have more than one correct answer even though this is not indicated anywhere in the book. Each puzzle is stated in the interesting form of a little story that gives the question added zest. A few of the correct answers will be declared wrong until they have been carefully demonstrated. The three dollars expended for the book will provide many hours of wholesome enjoyment.

G. W. W.

THE ELECTRONIC BRAIN AND WHAT IT CAN DO, by Saul Gorn, *Associate Professor at Moore School of Electrical Engineering, University of Pennsylvania*, and Wallace Manheimer, *Chairman Science Department, Forest Hills High School, New York City*, with Consultant Editor Paul F. Brandwein, *Science Editor for Harcourt, Brace and Company*. Paper. Pages 64. 13.5×21.5 cm. 1956. Science Research Associates, Inc. 57 West Grand Avenue, Chicago 10, Ill.

Names in the news often become symbols without sense. "Electronic brain," "digital computer," "feed back," "coding" are instances. By frequent repetition they come to be, mistakenly, considered as understood because of familiarity. Because of this subtle deception there is a needed service that such booklets as this can render.

In an informal preface it proposes to answer such questions as: What is a digital computer? Why are they called brains? Do they really think? How do they remember? How is it they work so much faster than human mental processes?

There are eight chapters averaging less than eight pages per chapter. A first has: "Who uses the thinking machines?" and an admonition that "all thinking is not the same." A second, about "Yes-no thinking," introduces the "game of twenty questions." In the third "Two card tricks" prepare the reader for coding. Chapter four has the "Machine in the picture" by means of a sort of census problem. Chapter five gives an operational account of a "Digital computer." In six the "operations" previously considered are geared to the machine. Its mechanisms that perform, following the steps in those operations, are pin-

pointed and the resemblances of machine responses to human are considered. In chapter seven necessity of coding of an assignment, to be serviced in the machine, is stressed. How it is done and why, get chief emphasis. A final chapter, under the heading "The computer and you," briefly assesses both present as well as possible future activities in which it may enter.

Thirty two diagrams, thirteen cartoon-type drawings and two photo-plates enliven and graphically aid the verbal exposition. An eight item reference list "For further reading" is appended but no index.

"The electronic brain at work" will have little to offer the expert in automation. However, the novelty and unexpectedness of some of the devices used for intriguing and leading the reader into the intricacies of the mechanism may entertain. This reviewer doubts if there is a more effective help for inducing a keenly curious youngster to probe the "mysteries of the electronic brain" than that in this modest booklet.

B. CLIFFORD HENDRICKS,
457 24th Ave., Longview, Wash.

ATOMS AND ENERGY, by H. S. W. Massey, F. R. S., *Professor of Physics, University of London*. Cloth. 174 pages. 13.5×21.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price \$4.75.

This "non-technical account of the developemnts in atomic physics" is different in that here we have not only the historic sequence of events that eventuated in the nucleonics of today but a careful concern for the inter-relations of factual findings in the web of the evolving theory. In a sense this will have an especial appeal to the non-physical scientist for its presentation is in the pattern of the scientific approach. That, however, will not deter the non-scientific reader from following the presentation for its phraseology and descriptive effectiveness are attention-holding for all who have a yen to know.

Six chapters give attention, in due order, to: Atoms and nucleons; Atom combinations, Chemical energy; Nuclear changes; Nuclear energy; Services of nuclear energy, and finally, Current researches in nuclear physics. An outline type of table of contents permits the time-limited reader to anticipate that which any section, of those chapters, is promising for his reading investment. A six page index also encourages one who comes to the book with specific needs in mind. No bibliography is offered and most references, within the text, are to the work of English investigators. Six tables and thirty-seven figures, the last with helpful descriptive legends appended; are aids to added clarity.

The author was head of a group of British scientists who worked in America on the Atom Bomb project and has published three standard monographs on theoretical aspects of atomic physics. Fortunately he has a skill, so often found among his English colleagues, that makes his presentation in his book attractive as well as authentic for the reader. It is interesting reading that carries more than added facts.

B. CLIFFORD HENDRICKS

PEOPLE AND TIMBER, A Condensed Summary of the Timber Resources Review. Paper. 15 pages. 19.5×25.0 cm. June, 1956. Superintendent of Documents, U. S. Government Printing Office. Washington, D. C. Price \$.15.

This story of our timber, as of today, also considers the population increase for the years ahead in relation to demands likely to be made upon its timber resources. It comes up with the conviction that "we have to plan ahead" if our posterity is to enjoy the abundance that is ours today.

This booklet, by graphic and pictorial aids, should induce even the slow reader to become concerned. An excellent "first aid" to students of conservation and natural resources.

B. CLIFFORD HENDRICKS

RAW MATERIALS OF STEELMAKING. Paper. 20 pages. 14.0×22.0 cm. A Manual for a Film Strip. American and Steel Institute, 150 East Forty-Second Street, New York 17, N. Y.

It reproduces twenty seven of the frames with notes on nineteen. It is the third of a series including Chemistry of Iron and Chemistry of Steel. Five and one half pages of teaching aids and bibliography are offered.

B. CLIFFORD HENDRICKS

IRRATIONAL NUMBERS, The Carus Mathematical Monographs, No. 11, by Ivan Niven, *Professor of Mathematics, University of Oregon*, Cloth. Pages xii+164. 13×19.5 cm. 1956. Published by The Mathematical Association of America, Distributed by John Wiley and Sons, Inc., New York. Price \$3.00.

As the author suggests, "This monograph is intended as an exposition of some central results on irrational numbers, and is not aimed at providing an exhaustive treatment of the problems with which it deals." The reader of this book should be familiar with calculus and elements of number theory. Certain portions of this work assume that the reader has a knowledge of algebraic number theory and function theory.

Discussions of the irrationality of the numbers of elementary analysis, such as π and e , are included. The author covers the subject of the irrationality of certain trigonometric functions and hyperbolic functions. Other topics of this book deal with the approximation of irrationals by rationals, continued functions, Diophantine approximations, normal numbers, the generalized Lindemann theorem, and the Gelfond-Schneider theorem.

The primary emphasis tends to be on those aspects of irrational numbers commonly associated with number theory. This monograph contains a list of notation and a glossary of terms, both of which should prove beneficial to the reader. The author has made it a practice to terminate each chapter with "notes" on the chapter. These "notes" include items of historical interest, as well as, pertinent subject matter references. There is also a list of reference books in the back of this treatise.

This book should prove to be an excellent reference on the subject of irrational numbers.

J. RAY HANNA
University of Wichita

INFINITE SEQUENCES AND SERIES, by Konrad Knopp, *Emeritus Professor of Mathematics at the University of Tübingen*, Translated by Frederick Bagemihl, *The Institute for Advanced Study*. Paperbound. Pages v+186. 14×20.5 cm. 1956. Dover Publications, Inc., New York, N. Y. Price \$1.75.

It is assumed that the reader of this book be familiar with the concepts of both functions of real and complex variables.

In the introductory chapter, definitions and fundamental ideas concerning sequences and series are presented. A brief introduction of infinite products is also included. Agreements concerning the notation and types of numbers assumed are adequately indicated. The first chapter contains a very informative discussion of the prerequisites necessary for the reader to pursue the content of this work.

Although this book treats the subject of series and sequences in an expository way, frequently there are included well selected illustrations and examples. The wide range in the selection of material should be a contribution of interest to both the pure and applied mathematician. This book treats such subjects as Cauchy's limit theorem and its generalizations, tests for sequences, the main tests for infinite series, and operations with convergent series. One chapter is devoted to power series, including such topics as functions represented by power series, operating with power series, and the inversion of a power series. Other chapters are devoted to the development of the theory of convergence and the expansion

of elementary functions. The last chapter is concerned with numerical evaluations and estimations of remainders as well as closed evaluations.

Although it is possible that this book might be used as a text for those students with the proper background, it is perhaps better to recommend its use as an excellent reference for the serious student of mathematics. This economy volume is an excellent source on the subject of infinite series.

J. RAY HANNA

200 MILES UP—THE CONQUEST OF THE UPPER AIR, by J. Gordon Vaeth, *Head, New Weapons and Systems Division, U. S. Navy Special Devices Center, Office of Naval Research*. Cloth. Pages xiii+261. 15×24 cm. 1955. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. \$5.00.

This book is the second edition of a text which appeared in 1951. It brings the original material up to date and ventures a look at the future of upper air research. Its issuance is timely with current interest in the International Geophysical Year (1957-1958).

The content is made up of three parts. The first is a summary of present understanding of the nature of the earth's atmosphere. The bulk of the material following describes the instruments, vehicles, and techniques through which these concepts have been gained. The final section probes the immediate and distant future on the basis of man's achievements to date in extending the frontiers of space knowledge.

The author makes an admirable attempt to summarize a vast amount of technical and theoretical material in simple, concise terms. To many this will seem an impossibility in such an elementary presentation. An understanding of the theoretical aspects of upper air research can not be gained from this volume. It seems to the reviewer that the primary value of the book lies in the realistic appreciation of scientific exploration gained by the reader.

It is difficult to assess the level at which the material is aimed. Many terms are inadequately explained for a truly basic approach, yet others equally important to the text receive careful treatment. However, the content involves much that is new, and parts of the book will be of value to anyone who reads it. It is clear that an elementary knowledge of physics and chemistry will greatly facilitate the reader. The earlier parts are too technical to be classed as popular material. The latter descriptive chapters are very well written and should appeal to anyone. There are many excellent illustrations and photographs. The book is definitely not reference material, and it is not footnoted nor is a bibliography presented. It covers too large an area to dig deeply. It is my opinion that the book will be of interest to the above average high school student with scientific interests and to a few adult readers. It is the type of book which should be available in good high school and public libraries.

Noteworthy is the fact that the non-military aspects of scientific research are emphasized. It is clearly shown why the minimum satellite and other future projects are not aimed at control of the world as is popularly conceived. The following quotation is indicative of the author's attitude and is an important message to the lay world: "providing new scientific information to be shared with all the nations of the world . . . will contribute to international friendship, co-operation, and understanding . . . may well prove to be the most meaningful and most lasting of all the achievements of the minimum earth satellite."

ROBERT C. NAGLER
*Western Michigan College
Kalamazoo, Michigan*

COLLEGE ALGEBRA, Revised Edition, by Edward A. Cameron, and Edward T. Browne, *The University of North Carolina*. Cloth. Pages x+390. 15.5×23.5 cm. 1956. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price \$4.25.

In general, this text fits the traditional course in College Algebra. It builds solid foundations on which future mathematics can continue. The material concerning determinants, for example, can be expanded to determinants of any order. In a few cases a statement could be more definite as in Example 2, page 88, where x is defined as the digit in the tens' place, then is used in the units' place in the new number.

The authors present a very good definition of division when dividing one fraction by another then state the rule involving "invert the divisor and multiply." It appears that this rule could very easily be omitted after the students have been presented the previous material in the text. A chapter on introductory statistics has been added in this revision. This chapter, in addition to the chapters on infinite series and partial fractions, makes the text more versatile than many. The paper and binding appear to be of good quality. Ample exercises are provided so that selections may be made within each set. Answers are given for the odd-numbered exercises.

In final summary, this book is worthy of serious consideration as a text for a class in college algebra as it is well-written and clearly presents the material for the students.

OTHO M. RASMUSSEN
University of Denver

THE SCIENCES AND THE HUMANITIES

If this nation's science and technology ever achieve "the greatest good for the greatest number," some current educational trends must be reversed, a General Motors scientist warned here tonight.

Addressing the Scientific Research Society of America (RESA), whose board of governors voted him the Society's Proctor Prize as one of the nation's leading scientists, Dr. Lawrence R. Hafstad made a plea for reviving classroom disciplines of science and mathematics for both technical and non-technical high school students.

Presentation of the award was made at a combined meeting of RESA and Sigma Xi, national scientific fraternity, in connection with the annual meeting of the American Association for the Advancement of Science.

Dr. Hafstad, vice president in charge of General Motors Research Staff, explained that to reap full benefits of technology, a "good society" not only must train more scientists and engineers but also must make the basic philosophies of science understandable to non-technical people.

He cited a recent Purdue University survey of high school student attitudes toward career scientists, indicating varying percentages of students believed scientists are "odd," dishonest, incapable of enjoying normal lives and willing to sacrifice the welfare of others to further their own interests.

"This is indeed a devastating comment—either on scientists or on our educational process or both," Dr. Hafstad declared.

"Since the world managed to survive for some centuries before the advent of scientists or engineers, (these) attitudes . . . would be quite understandable, if the students were or proposed to become mystics and lead the contemplative life, which certainly has its advantages.

"But these were normal American boys and girls demanding and getting one hundred horsepower cars for transportation, radios, television, movies, juke boxes and all other paraphernalia of our modern civilization. How could they have grown to college age without learning the simple facts of cause and effect with respect to the technological civilization in which they are clearly planning to live?" he asked.

"In this respect," Dr. Hafstad said, "our school system is inadequate, in my opinion. The shortage of scientists and engineers is bad enough, but with some effort these immediate shortages can be corrected since the total numbers needed are not really large in proportion to the population.

"What is more serious (and more dangerous in the long run) is that the mass of our population, who in a society dedicated to the greatest good for the greater number . . . , remains in ignorance of the foundations on which that society is based," he added.

Dr. Hafstad told his scientist audience his greatest concern was "a continuing divergence in point of view between the sciences and the humanities."

"With increasing complexity and specialization in the technical fields," he said, "the gap between the sciences and the humanities becomes an ever widening one. This adverse tendency could be reduced by insuring that students of science were given a better grounding in the humanities, while students in the humanities were given a better background in science."

"This, however, would require more rather than less disciplined study in both fields, and runs counter to current educational trends."

"Much of the energy of our educational system these days is focused on new theories of teaching which . . . avoid grading and thus any semblance of conflict or competition. This is desirable sociologically, but apparently so is a rising standard of living. This presents a painful choice. In technology, if incentive is removed, so is struggle—and if struggle is stopped, so is progress," he declared

WISCONSIN'S RENEWABLE RESOURCES

A new book on Wisconsin—describing research conducted at the University of Wisconsin on the state's resources in field, forest, lake, and stream—has been published by the University and the Wisconsin Alumni Research Foundation.

The volume, written by James A. Larsen, science editor of the University of Wisconsin News Service, is a detailed review of research findings by hundreds of University scientists—findings which have furnished a working knowledge of trees, soil, fish, and game.

The author points out that the theme of "Wisconsin's Renewable Resources" is that research has helped solve many of the problems posed by the need to "manage wisely and well the natural, renewable resources of Wisconsin."

The volume runs to 160 pages and is illustrated with nearly 50 photographs of Wisconsin scientists at work. It presents a summary in non-technical style of research at Wisconsin which has pointed the way for better management of native vegetation of forested lands and prairies, of game animals such as quail, deer, pheasant, Hungarian partridge, waterfowl, the grouse species, and of lakes and the fish in them. There are 27 chapters—each devoted to a special aspect of the University's past and present research on resources.

A copy of the volume has been provided each town and city library and every high school in the state free of charge by the Wisconsin Alumni Research Foundation.

BIGHORNS ROAM AGAIN IN NORTH DAKOTA BADLANDS

Eighteen bighorn sheep, obtained from the British Columbia Game Commission, were released in the Badlands of North Dakota in an attempt to re-establish these big game animals in the Badlands. A 200-acre pasture was fenced off on federal land in the rough country west of Grassy Butte, in McKenzie County. The new home of the bighorns is located in some of the most rugged country in the state, directly west of Grassy Butte, deep in the badlands of the Little Missouri River.

Bighorn sheep were native to the Badlands of North Dakota before the turn of the century. They were hunted by early settlers, trappers and explorers. However, they completely disappeared, along with the grizzly bear and buffalo. State biologists expect the introduction of these 18 sheep to be the nucleus of a future herd of bighorns in North Dakota. They will be kept inside the huge pasture for at least one year, in order that a close watch can be kept over their progress.

4

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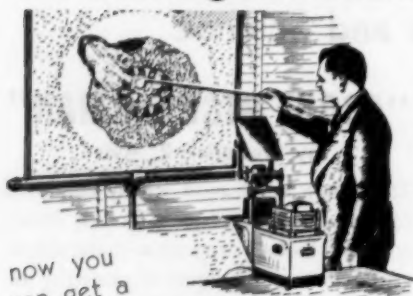
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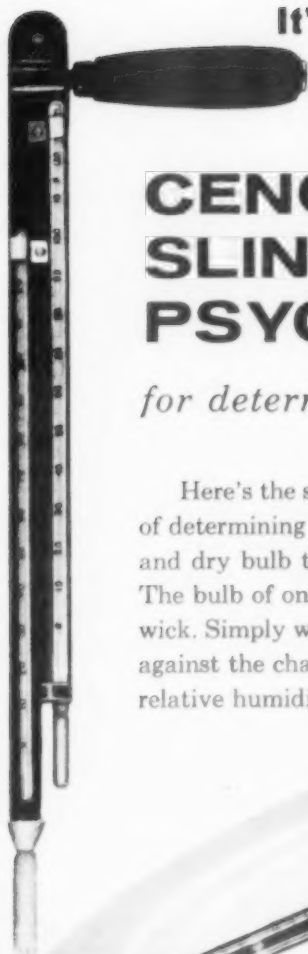
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